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BRITISH ASSOCIATION  
FOR THE ADVANCEMENT  
OF SCIENCE

REPORT

OF THE

ANNUAL MEETING, 1936  
(106<sup>TH</sup> YEAR)



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## CORRIGENDA.

## SECTION A. PRESIDENT'S ADDRESS.

Page 37, line 18. For 'preceptual' *read* 'perceptual.'

Page 39, line 9 from foot. For 'correction' *read* 'connection.'



# British Association for the Advancement of Science.

## FIVE YEARS' RETROSPECT

1931-1935

(ISSUED IN APRIL, 1936).

THIS Summary Report is intended by the Council to be the first of a series dating from the beginning of the Association's second century, in 1931. Its principal purpose is, not to review the transactions of the annual meetings, but to illustrate by examples the perennial activities of the Association which arise from or are supplementary to those transactions.

### I. ANNUAL MEETINGS.

By way of introduction, however, a summary reference to the annual meetings themselves is desirable. The following table shows (1) the places of meeting, (2) the presidents of the Association, and (3) attendances of members.

| Year. | (1)       | (2)  | (3)   |
|-------|-----------|--|-------|
| 1931  | London    | Gen. the Rt. Hon. J. C. Smuts, P.C., C.H.,<br>F.R.S. | 5,702 |
| 1932  | York      | Sir Alfred Ewing, K.C.B., F.R.S.                     | 2,024 |
| 1933  | Leicester | Sir F. Gowland Hopkins, O.M., Pres. R.S.             | 2,268 |
| 1934  | Aberdeen  | Sir James H. Jeans, F.R.S.                           | 2,938 |
| 1935  | Norwich   | Prof. W. W. Watts, F.R.S.                            | 2,321 |

The following observations should be made concerning this table.

It is common knowledge that the Association had never before 1931 held its annual meeting in London; it is not ordinarily its function to do so, and its statutes lay down that the Association 'contemplates no invasion of the ground occupied by other institutions,' a disclaimer always understood as referring particularly to the other great learned societies whose headquarters are in London. Nevertheless, for the Centenary Meeting, in 1931, London was chosen by common consent, at the expressed wish of the Corporation of the City of London, and with the generous co-operation of the London County Council, the University of London, and many other bodies. Accommodation for meetings was provided mainly by the Imperial College of Science and Technology. York was the birth-place of the Association in 1831, but it was felt that so large a meeting as the Centenary was expected (and proved) to be could not be conveniently arranged there. The President and other officers and members made pilgrimage to York during the week-end of the Centenary, and the meeting in the following year was held there.



To the list of presidents of the Association it is necessary to add the name of Sir William Hardy, F.R.S., who was elected to office for the year 1934. He died on January 23 of that year, and was succeeded by Sir James Jeans, F.R.S. At the Aberdeen Meeting one of the Evening Discourses was made a memorial lecture for Hardy; it was given by Sir Frank Smith, K.C.B., Sec. R.S., and dealt with the Storage and Transport of Food, illustrating the far-reaching results of Hardy's work.

On the figures of attendances of members at the annual meetings it is to be remarked that there has never been previously a continuous succession of five years in each of which the numbers have exceeded 2,000. This is evidence of a widening of the appeal of the Association; the fluctuation of numbers from year to year has little significance in this connection, since the attendance in any particular town is affected by various considerations, such as its size (which reacts upon the local membership for the meeting), the existence of a university or other strong scientific element, the scientific interests of the locality, etc.

In 1932 an important change was made in the period of the presidential office. It now coincides with the calendar year, instead of beginning with the annual meeting. The principal argument in favour of this change was that the President is responsible administratively for the major part of the preparations for the annual meeting over which he is elected to preside and his influence can be more directly brought to bear upon them. The first official act of the new President is now to preside over the joint meeting of the Organising Sectional Committees when, in January of each year, they lay down the main lines of the programme for the ensuing annual meeting.

In this connection it is appropriate to refer to the strong demand recently encountered in the press and elsewhere that in the programmes of the Association more systematic attention should be paid to the bearings of scientific progress upon the welfare of the community. Efforts have been and are being made to meet this demand, and not only in the transactions of the annual meetings themselves. For in 1935 the Council decided to initiate a series of quinquennial reviews of the progress of science (without particular reference to the proceedings of the Association): the first of these reviews, covering the period 1931-1935, is in preparation, and is intended to be published by Messrs. Sir Isaac Pitman & Sons in the autumn of 1936.

In 1931-1932 the Council considered in detail those expenses connected with annual meetings which fall upon the locality in which the meetings are held, and are met each year by a local fund. It was felt that such expenses might tend, and indeed had tended, to increase unduly in sympathy with the general rise of prices in the past twenty years; but the Council were able to make certain arrangements and proposals for the guidance of local committees which have counteracted this tendency. One result of this action has been the production of a systematic series of scientific surveys of each successive place of meeting and its neighbourhood, in place of the handbooks formerly produced by local committees on no fixed model and sometimes at very large cost. The new series has made for economy of production, and for a definite increase of scientific value inasmuch as in course of time large areas of the whole country will be covered by orderly studies of their outstanding scientific interests. These, moreover, will in



future provide historical records of interest, when, in course of time, the Association revisits centres for which surveys have been previously compiled, as they will afford material for the study of changes during the periods intervening between visits. Out of the four surveys which have been produced under this scheme (for the meetings at York, Leicester, Aberdeen, and Norwich), those for Leicester and Norwich were reprinted in substantial quantity for educational use at the instance of the respective local authorities.

## II. RESOLUTIONS AND RECOMMENDATIONS.

Among the numerous duties of the Council of the Association (the executive body which remains in session throughout the year and holds six ordinary meetings) is that of dealing with resolutions and recommendations formulated in the Sections or otherwise during the annual meeting. During the quinquennium twenty-nine such resolutions and recommendations were referred to the Council for consideration, and for action if desirable. They dealt, among other topics, with such diverse questions as :

- An inland water survey for Britain (1934).
- Preservation of the countryside, and national parks (1934, 1935).
- Reduction of noise of motor vehicles (1932, 1935).
- Easement for the importation of technical scientific cinema films, apparatus, and specimens (1931, 1934).
- Establishment of a nature reserve in the Galapagos Islands (1935).
- The ill effects upon bird life caused by cutting hedgerows during nesting time (1935).
- Extermination of the muskrat in Britain (1933).
- Preservation of wild fauna in Africa (1931).
- Revision of Ordnance Survey Maps (1933).
- Extension of geodetic surveys in British colonies and dependencies (1933).
- Continuation of an atlas of geographical types (1934).
- Desirability of including maps showing relative density of population in census reports (1931, etc.).
- Aerial photography of topographical features (1932).
- Disposal of finds from caves in Derbyshire (the exploration of which had long been supported by the Association) and the preservation of certain of the caves (1931, 1935).
- Specification for the lower yield-point of mild and moderately high-tensile steel (1935).
- Diseases of the cricket-bat willow (1933).
- Provision and publication of agricultural statistics (1932).
- Interchange of museum specimens (1932).

The manner in which each resolution or recommendation has been dealt with is stated by the Council in their yearly report to the General Committee, and may be found by reference to the appropriate Annual Report of the Association (i.e., usually, that for the year following the date given in the preceding paragraph). The Council were able to deal with some of these questions by referring the resolutions forthwith to appropriate Government

departments, or to other institutions more directly concerned than the Association. Some, however, were matters to which the mechanism of the Association itself could be more closely applied, and by way of example the procedure followed in connection with the first six subjects in the preceding list will now be briefly outlined.

The interest of the Association in a survey of the inland water resources of the country was awakened (or rather reawakened, for in earlier years committees of the Association had done work on certain aspects of this question) by a discussion at the York Meeting in 1932, after which a committee was appointed to inquire into the position of inland water survey in Britain, and the possible organisation and control of such a survey by central authority. Its reports will be found in the Annual Reports of the Association for 1933 (p. 358), 1934 (p. 239), and 1935 (p. 324). Following upon the issue of the first of these reports, the co-operation of the Institution of Civil Engineers was secured, and a letter and memorandum on the desirability of a complete and systematic survey of the water resources of the country were addressed by the Presidents of the Association and the Institution to the Prime Minister. A representative deputation subsequently waited upon the Minister of Health to discuss the matter, and in February, 1935, it was announced that the Government had appointed a committee to advise on the inland water survey for Great Britain, on the progress of the measures undertaken, and on further measures required. The Council of the Association later appointed a watching committee in case occasion should arise for further intervention. Meanwhile (1934), in the same connection, a resolution forwarded to H.M. Government had urged the compulsory registration of wells, borings and excavations exceeding 100 ft. in depth.

Questions relating to the preservation of the countryside, national parks, and nature reserves have been brought before the Association more than once during the period under review, both in sectional meetings and in the appropriate setting of the annual conference of delegates from the corresponding societies (local scientific societies affiliated to or associated with the Association). As mentioned above, resolutions have been put forward urging, among other matters, more systematic instruction in schools concerning the preservation of natural vegetation, the protection of bird life by the avoidance of hedge-cutting during the nesting season, the more adequate provision of nature reserves, and the protection from building development of areas which might become national parks. In 1934 the Ministry of Health began to inform the Association of the progress of planning all over England and Wales under the Town and Country Planning Act, in order that the Council, if they thought fit, might call attention to the desirability of protecting any area or site of scientific interest. The Council informed the corresponding societies of this, and also appointed a panel of persons from whom expert advice might be invited in case of necessity. The Association, at the invitation of the Council for the Preservation of Rural England, was represented on a deputation which urged upon the Air Ministry the protection of Chesil Beach and the Abbotsbury Swannery from the effects of aerial bombing practice.

The subject of noise, principally of motor vehicles and aircraft, has engaged the attention of the Engineering Section (G) and that of Mathematical and Physical Sciences (A) at more than one meeting. Resolutions



have been addressed to H.M. Government (1932, 1935), and in 1933 a committee of the Engineering Section was appointed to review the knowledge available for the reduction of noise. This committee informed itself by inquiry through the press as to public feeling against the various classes of noise emitted by motor vehicles and aircraft. Research upon the silencing of motor-cycle engines was carried out, and its results were effectively demonstrated at the Aberdeen Meeting in 1934. The Committee's statement in the Report for that year (p. 252) indicates the results both of its public enquiry and of the research referred to. Subsequently to the appointment of this committee, a committee was set up by the Ministry of Transport to investigate the whole question.

As the result of a report received, not through any Section of the Association itself but from the Association of British Zoologists, the Council in 1931 appointed a committee to consider action with a view to the amelioration of customs regulations affecting the importation of scientific specimens and apparatus. The Custom House authorities supplied the Association with a memorandum on the reliefs from customs duties on scientific instruments and cinematograph films, in order that advice might be given as required to scientific workers, and also a note on the importation of scientific specimens in spirit, which is published in the Report, 1932, pp. xxi-xxii. In 1934 it was pointed out to the Council, by resolution from Section D (Zoology), that although technical cinematograph films for the advancement of scientific knowledge may be imported duty free for exhibition before scientific institutions, there was no provision for the free importation of films for the teaching of science in universities and similar institutions. It was ascertained, however, from the British Film Institute<sup>1</sup> that an international convention was expected to be concluded to cover, *inter alia*, such cases as those reported to the Council.

The Council were made aware in 1933 of measures in progress to establish a nature reserve in the Galapagos Islands. The interest of the Association is peculiarly engaged in this question, since Darwin's house at Downe, Kent, is in its charge as a national memorial (Section IV, below), and Darwin's investigations of the unique fauna of the Galapagos Islands helped fundamentally to influence the views which were given expression in *The Origin of Species*. The Council were subsequently informed of action by the Ecuadorean Government, which, by decree, made possible the reservation of certain of the islands and the protection of the fauna of scientific interest. The gratification of the General Committee at this measure was conveyed from the Norwich Meeting (1935) to the Ecuadorean Government and was acknowledged, and the Council appointed representatives of the Association to act on any international or other joint committee which might be formed to expedite the establishment of the reserve. The centenary of Darwin's landing in the islands (September, 1835) was pleasantly marked by the receipt of a cablegram from the present H.M.S. *Beagle*, recalling that 'a hundred years ago our most distinguished passenger landed' there, and continuing: 'the present *Beagle* salutes the British Association, the trustees of Science.'

<sup>1</sup> On the formation of this institute, see p. xii.



## III. RESEARCH.

The average number of research committees appointed or reappointed by the General Committee at each annual meeting during the period, and carrying on their work during the ensuing year, was fifty-two. Of these, again on average each year, twenty-six received grants of money from the funds of the Association. The total expenditure on grants to research committees, during the nearest period to the quinquennium for which completed accounts are available,<sup>2</sup> was £6,173 10s. 5d., which is the highest in any quinquennial period since 1831, excepting one.<sup>3</sup> The average quinquennial expenditure on grants since 1831 has been £4,900. Some further reference to this aspect of the Association's activities will fall under the later heading of Finance (Section V).

The Association has maintained its support of the researches carried on, under committees, by selected workers at the marine laboratory, Plymouth, the zoological station at Naples, and the freshwater biological station at Wray Castle, Windermere. Proposals for the establishment of a freshwater biological station originated at the meetings of the Association in 1927-28; the preliminary work of a committee formed thereafter was followed by the creation of the Freshwater Biological Association of the British Empire, and in 1931 the Wray Castle Station was opened, with financial assistance from H.M. Government, the Royal Society, the Fishmongers Company, the Manchester Waterworks Committee, the Metropolitan Water Board, and other learned societies, institutions, and individuals.

The prolonged connection of the Association with seismological research, the calculation of mathematical tables, the publication of the *Zoological Record*, and the collection and registration of geological photographs has been continued.

The Seismology Committee—and no less the Association as a whole—lost an outstanding supporter on the death of Prof. H. H. Turner, F.R.S., in 1930. The publication of the *International Seismological Summary*, which he initiated, was continued. In 1933 the University of Oxford agreed to house and to meet part of the operating expenses of the *I.S.S.* Reports on earthquakes both in this country and abroad have been regularly presented, together with notes on research embracing such questions as periodicity, travel and transmission times, long-wave phases and prediction of earthquakes. In 1935 the Association published a *Catalogue of Earthquakes* for 1925-1930 inclusive (*Annual Report*, 1935, p. 230), based on the *International Seismological Summary*, and compiled by Miss E. F. Bellamy in continuation of the previous catalogue compiled by Prof. Turner (1928).

During the quinquennium the following volumes have been published

<sup>2</sup> Viz. July 1, 1930, to March 31, 1935. The period is three months short of a complete quinquennium because the dates of the financial year were changed in 1932-33.

<sup>3</sup> This was the period 1866-70, when about £8,600 was paid. A policy of accumulating funds had apparently been in force before that time but had been reversed; moreover the Association was then devoting substantial sums to the committee charged with the maintenance of Kew Observatory, which was transferred to the control of the Royal Society in 1872.

under the direction of the Mathematical Tables Committee : (1) *Circular and Hyperbolic Functions, Exponential Sine and Cosine Integrals, Factorial (Gamma) and Derived Functions, Integrals of Probability Integrals* (1931); (2) *Emden Functions* (1932); (3) *Minimum Decompositions into Fifth Powers* (1933); (4) *Cycles of Reduced Ideals in Quadratic Fields* (1934); (5) *Factor Tables* (1935). In preparation are *Bessel Functions*, which are expected to extend to three volumes, the first of which was in the press at the end of 1935. The Cambridge University Press are now the publishers of these volumes.

The Committee on Geological Photographs is that of longest lineage among existing research committees of the Association: it was first established in 1873. The Committee published two additional lists in 1931 and 1935, bringing the number of photographs in the collection to 8,711. The collection is housed in the library of H.M. Geological Survey, South Kensington, and was recently overhauled. Prints and lantern slides of certain of the photographs are on sale to the public.

Further illustration of the scope of the Association's research work must be restricted here (with one exception) to examples of the work of committees which have completed their tasks. The work of the committees on Inland Water Survey and on Noise has been mentioned in an earlier section (II).

Provision for research in chemistry through other channels is so far adequate that this subject makes relatively little demand upon the Association (and the same applies to agricultural research). Nevertheless, in 1932 a committee appointed to collect and tabulate all available data concerning the parachors of chemical compounds published a list giving in convenient form data for 638 substances (*Annual Report*, 1932, p. 264).

In 1931 a committee appointed to organise an expedition to investigate the biology, geology and geography of the Australian Great Barrier Reef presented its final report, which stated that the Trustees of the British Museum had undertaken the full publication of their work. A fitting sequel to the work of the expedition was the establishment, by the Queensland Government, of a Permanent Marine Biological Service, the huts, equipment, and scientific library of the committee forming the nucleus of the first marine laboratory to be established in Australia.

In 1935 the Biological Measurements Committee published a booklet under the title *Biological Measurements*, being a revised edition of recommendations made previously (1927). This is intended to assist in bringing the biological sciences into line with certain aspects of the more exact physical sciences.

The committee appointed with a grant in 1929 to facilitate the investigations of Dr. M. C. Rayner on tree mycorrhizas (associations of fungi with living roots) finally reported in 1932. Dr. Rayner's further researches on this subject are now being assisted financially by the Forestry Commission.

Among psychological researches, the committee on the Reliability of the Criteria used for assessing the Value of Vocational Tests presented in 1931 a survey of their work. As a result, the Industrial Health Research Board started an extensive investigation in which the after-careers of some 2,000 apprentices were compared with their performances



in scholastic and psychological tests at the time of beginning their apprenticeships. The investigation was the direct outcome of interest stimulated by the work of this research committee.

A committee on Vocational Tests made a survey of tests by collecting and analysing these with a view to assisting in the work of vocational guidance. In its final report in 1933 appeared a valuable analysis of the factors involved in mechanical ability. A further investigation into the factors involved in manual dexterity arose out of this. The results obtained are of very great practical importance.

In 1931 the Committee on Educational Training for Overseas Life presented its final report, which was mainly concerned with overseas careers for pupils from secondary schools, and contains much information for boys and girls contemplating work in the Dominions. One thousand copies of this report were printed and distributed to all schools and institutions in the Empire which had contributed to its compilation.

A report presented in 1933 reviewed the position which geography occupies in the curricula of the universities of the Empire, particulars being published for Australia, New Zealand, India, South Africa and Canada. It was shown that geography does not yet occupy the important position in Dominion universities that it does in the universities of the home country. The report was distributed to the universities concerned.

A committee inquiring into the teaching of General Science in schools reported in 1933 (*Annual Report*, 1933, p. 312) that there was a general feeling that the traditional science curriculum comprising physics and chemistry had ceased to be adequate, and that biology was being widely introduced. The main difficulty was a shortage of competent teachers of biological subjects. This conclusion was endorsed by a separate committee on the teaching of botany (1932). Research in educational subjects has been continued by committees appointed during the quinquennial period, e.g. one committee reported on Science Teaching in Adult Education (*Annual Report*, 1933, p. 330), and other enquiries have dealt with the teaching of anthropology and animal biology in schools and psychology in the universities. It should be added that in 1935 a committee was appointed to report on the teaching of geology in schools.

The committee appointed in 1927 to enquire into various aspects of Documentary and Educational Films presented a first and very full report on technical questions relating to the use of films in schools which led to a general quickening of interest in this aspect of the use of films. Various members of the committee assisted in the enquiries, which culminated in the *Report of the Commission on Educational and Cultural Films* (June 1932), in which report many abstracts from the committee's first report were included. The Commission's report *The Film in National Life* advocated the formation of a British Film Institute, a proposal which received effect in October 1933.

Among other committees which completed their work during the quinquennium, reference is due to the Committee on the Distribution of Bronze Age Implements, whose work took the form of a catalogue now in the charge of the British Museum, where it is available for reference.

Finally, the Committee on the Chronology of the World Crisis is one of those which remain in being, but its efforts have resulted in the issue



in 1935 of an important work in economics under the title of *Britain in Depression*, published by Messrs. Sir Isaac Pitman & Sons, with the authority of the Council. This is a record of British industries since 1929 in which, in addition to chapters dealing with currency and banking and with industrial relations, there are twenty-one chapters dealing with separate industries by authoritative writers.

#### IV. DOWN HOUSE.

It was in 1929, and therefore outside the period of this review, that Mr. (now Sir) Buckston Browne, F.R.C.S., gave the Association Down House, Downe, Kent, the home of Charles Darwin from 1842 until his death in 1882, to be held in trust as a national memorial, freely open to the public. Appreciation of this most generous act of homage to the memory of one of the greatest names in the advancement of science has been so widely expressed as to need no repetition here. The memorial rooms and grounds have been visited, on an average, by over 7,000 persons each year during the period under review. During the Centenary Meeting of the Association (1931), nearly 700 members of the Association visited the house, and the President (General Smuts) and Sir Buckston Browne entertained there a large number of distinguished guests. The house and grounds are open daily from 10 A.M. to 6 P.M. from April to September, and from 11 A.M. to 4 P.M. from October to March, including Sundays, but excepting Christmas Day.

Sir Buckston Browne, with the aid of members of the Darwin family and others, had already in 1929 collected many articles of furniture, portraits and pictures, letters, and other objects, either Darwin's own or appropriate to the collection of Darwiniana; and during the quinquennium under notice a number of further gifts have been received. Darwin's library has been restored to his own study, on loan from Dr. A. C. Seward, F.R.S., Professor of Botany in the University of Cambridge, the library having been left by Sir Francis Darwin to the holder of that chair for the time being. In one of the rooms portraits of past presidents and others appropriate to the history of the Association are shown, together with some of the former series of presidential banners, and here also is a repository of early records of the Association, all too scanty, but including some dating from its foundation, and lately recovered by Prof. Sollas, F.R.S., in the Geological Department of Oxford University, where they had been preserved by John Phillips, the first secretary of the Association, afterwards Professor of Geology at Oxford. The garden at Down, long uncared for before the house was acquired, has been enriched by gifts of plants from Kew Gardens and the John Innes Horticultural Institution.

Many societies make Down House an objective in the course of excursions, and the Genetics Society held one of its meetings there in 1934. No regular scientific work has as yet been established there, though Miss Saunders of Goldsmiths College, and others, have been able to make some use of accommodation at the house for parties of teachers in training and other students working on plant ecology in the neighbourhood. A recent gift to the house afforded opportunity for an interesting investigation. In 1934 a box of seeds of flowering plants and vegetables

which had been Darwin's was found and presented to the house by Mr. Bernard Darwin, together with a letter from Alphonse de Candolle on his experiments. These are exhibited, but some of the seeds were withdrawn and tested for germination at Kew Gardens, and a few seeds of *Trifolium* germinated after a period of not less than fifty-three years and probably longer.

Sir Buckston Browne settled a generous endowment upon the house, and the Pilgrim Trust made a grant of £150 per annum for five years, with a promise of review after the final payment, which will be made in 1937. The Association, out of its general funds, had expended upon requirements incidental to the acquisition of the property, restoration, and subsequent maintenance, the sum of £3,751 down to the close of the financial year 1934-1935. It was decided in 1934 that any subsequent balance on the side of receipts should be placed in a suspense or maintenance fund for the house : at present no such fund exists, and the House Committee in 1935 expressed the hope ' that all those friends of Down House who may be in a position to aid in the maintenance of this unique charge will not fail to do so.'

## V. FINANCE.

During the period under review the financial position of the Association has been in a measure strengthened, though not yet sufficiently to assure the future in respect of its work and commitments.

On the side of accretion of its resources there have to be recorded :

(1) The receipt of a legacy of £2,000, without conditions, under the will of the Hon. Sir Charles Parsons, K.C.B., F.R.S., ex-President and, during his lifetime, a generous benefactor of the Association.

(2) The receipt of a legacy of £500, without conditions, under the will of Sir Alfred Ewing, K.C.B., F.R.S., ex-President.

(3) The receipt of a legacy of £1,000 under the will of Mr. Bernard Hobson, to form a fund bearing his name, from which the income is applicable to the promotion of definite geological research.

(4) A gift of £1,000 from the local committee for the Leicester Meeting, 1933, being the unexpended balance of the local fund raised in connection with that meeting. The income is applied to the assistance of a student or students working for the advancement of science with preference where possible in favour of a Leicester or Leicestershire worker, or otherwise by way of grants to appropriate research committees. This gift is named the Leicester and Leicestershire Fund, and in accepting it the Council recorded ' their appreciation of the action of the Leicester Committee in thus confirming, in a manner without precedent in the history of the Association, their interest in the advancement of science.'

On the other hand, the Centenary Fund, raised in 1930-1931, failed, in spite of the generosity of over 500 subscribers, wholly to cover the extraordinary expenses of the Centenary Meeting, whereas it had been hoped that it would both do that and provide at least the nucleus of an endowment fund for the future. The reason for this ill-success was obvious : the general financial conditions which supervened about that time made it ' clearly inopportune,' as the General Treasurer's report showed, ' to

press the appeal as strongly as it might have been pressed in favourable circumstances.' It is apparent from an earlier section of the present report that the Association has maintained, and even somewhat increased, its financial support of research ; moreover, it has initiated a contingency fund with a view to stabilising this support during any year when receipts from subscriptions may be unusually low or expenses unusually high—though it has not been possible to build up this fund at the intended rate of £500 per year for five years. Moreover, the Association is, and has been since 1926, dependent in respect of a substantial proportion of its annual liabilities upon the gift of £10,000 made in that year, for the general purposes of the Association, by the late Sir Alfred Yarrow, F.R.S., who made the condition that his gift should be completely expended, as to capital as well as interest, not later than 1947. The knowledge that it accorded with the donor's wish that this should be done has been welcome to the Council, especially when dealing with the finances of the Centenary Meeting and of Down House (referred to elsewhere) ; but his own foresight the more strongly prescribes that those concerned with the finances of the Association should look to the future. It is, therefore, appropriate to conclude with these two quotations from recent reports of Sir Josiah Stamp as General Treasurer :

'The activities and liabilities of the Association have increased, and further endowment will be essential to consolidate the position it has attained at the close of its first century.' (1931.)

'The expansion of the Association's membership and the strengthening of its financial foundations should be the object of all those who would further its interests.' (1933.)





# BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

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(To be appointed.)

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| The Rt. Hon. LORD RUTHERFORD OF NELSON, O.M., F.R.S. (1923). | Sir F. GOWLAND HOPKINS, O.M., Pres.R.S. (1933).           |
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*Secretary.*—Dr. C. TIERNEY.

*Local Secretary.*—Dr. G. A. ARMSTRONG.



## TABLE OF

| Date of Meeting      | Where held        | Presidents                                | Old Life Members | New Life Members |
|----------------------|-------------------|---|------------------|------------------|
| 1831, Sept. 27.....  | York .....        | Viscount Milton, D.C.L., F.R.S. ....      | —                | —                |
| 1832, June 19 ...    | Oxford .....      | The Rev. W. Buckland, F.R.S. ....         | —                | —                |
| 1833, June 25 ...    | Cambridge .....   | The Rev. A. Sedgwick, F.R.S. ....         | —                | —                |
| 1834, Sept. 8 .....  | Edinburgh .....   | Sir T. M. Brisbane, D.C.L., F.R.S. ...    | —                | —                |
| 1835, Aug. 10 .....  | Dublin .....      | The Rev. Provost Lloyd, LL.D., F.R.S.     | —                | —                |
| 1836, Aug. 22 .....  | Bristol .....     | The Marquis of Lansdowne, F.R.S. ...      | —                | —                |
| 1837, Sept. 11.....  | Liverpool .....   | The Earl of Burlington, F.R.S. ....       | —                | —                |
| 1838, Aug. 10 .....  | Newcastle-on-Tyne | The Duke of Northumberland, F.R.S.        | —                | —                |
| 1839, Aug. 26 .....  | Birmingham .....  | The Rev. W. Vernon Harcourt, F.R.S.       | —                | —                |
| 1840, Sept. 17 ..... | Glasgow .....     | The Marquis of Breadalbane, F.R.S.        | —                | —                |
| 1841, July 20 .....  | Plymouth .....    | The Rev. W. Whewell, F.R.S. ....          | 169              | 65               |
| 1842, June 23 .....  | Manchester .....  | The Lord Francis Egerton, F.G.S. ....     | 303              | 169              |
| 1843, Aug. 17 .....  | Cork .....        | The Earl of Rosse, F.R.S. ....            | 109              | 28               |
| 1844, Sept. 26 ..... | York .....        | The Rev. G. Peacock, D.D., F.R.S. ...     | 226              | 150              |
| 1845, June 19 .....  | Cambridge .....   | Sir John F. W. Herschel, Bart., F.R.S.    | 313              | 36               |
| 1846, Sept. 10 ..... | Southampton ..... | Sir Roderick I. Murchison, Bart., F.R.S.  | 241              | 10               |
| 1847, June 23 ...    | Oxford .....      | Sir Robert H. Inglis, Bart., F.R.S. ...   | 314              | 18               |
| 1848, Aug. 9 .....   | Swansea .....     | The Marquis of Northampton, Pres.R.S.     | 149              | 3                |
| 1849, Sept. 12 ..... | Birmingham .....  | The Rev. T. R. Robinson, D.D., F.R.S.     | 227              | 12               |
| 1850, July 21 .....  | Edinburgh .....   | Sir David Brewster, K.H., F.R.S. ....     | 235              | 9                |
| 1851, July 2 .....   | Ipswich .....     | G. B. Airy, Astronomer Royal, F.R.S.      | 172              | 8                |
| 1852, Sept. 1 .....  | Belfast .....     | Lieut.-General Sabine, F.R.S. ....        | 164              | 10               |
| 1853, Sept. 3 .....  | Hull .....        | William Hopkins, F.R.S. ....              | 141              | 13               |
| 1854, Sept. 20 ..... | Liverpool .....   | The Earl of Harrowby, F.R.S. ....         | 238              | 23               |
| 1855, Sept. 12 ..... | Glasgow .....     | The Duke of Argyll, F.R.S. ....           | 194              | 33               |
| 1856, Aug. 6 .....   | Cheltenham .....  | Prof. C. G. B. Daubeney, M.D., F.R.S.     | 182              | 14               |
| 1857, Aug. 26 .....  | Dublin .....      | The Rev. H. Lloyd, D.D., F.R.S. ....      | 236              | 15               |
| 1858, Sept. 22 ..... | Leeds .....       | Richard Owen, M.D., D.C.L., F.R.S.        | 222              | 42               |
| 1859, Sept. 14 ..... | Aberdeen .....    | H.R.H. The Prince Consort .....           | 184              | 27               |
| 1860, June 27 .....  | Oxford .....      | The Lord Wrottesley, M.A., F.R.S. ...     | 286              | 21               |
| 1861, Sept. 4 .....  | Manchester .....  | William Fairbairn, LL.D., F.R.S. ....     | 321              | 113              |
| 1862, Oct. 1 .....   | Cambridge .....   | The Rev. Professor Willis, M.A., F.R.S.   | 239              | 15               |
| 1863, Aug. 26 .....  | Newcastle-on-Tyne | Sir William G. Armstrong, C.B., F.R.S.    | 203              | 36               |
| 1864, Sept. 13 ..... | Bath .....        | Sir Charles Lyell, Bart., M.A., F.R.S.    | 287              | 40               |
| 1865, Sept. 6 .....  | Birmingham .....  | Prof. J. Phillips, M.A., LL.D., F.R.S.    | 292              | 44               |
| 1866, Aug. 22 .....  | Nottingham .....  | William R. Grove, Q.C., F.R.S. ....       | 207              | 31               |
| 1867, Sept. 4 .....  | Dundee .....      | The Duke of Buccleuch, K.C.B., F.R.S.     | 167              | 25               |
| 1868, Aug. 19 .....  | Norwich .....     | Dr. Joseph D. Hooker, F.R.S. ....         | 196              | 18               |
| 1869, Aug. 18 .....  | Exeter .....      | Prof. G. G. Stokes, D.C.L., F.R.S. ...    | 204              | 21               |
| 1870, Sept. 14 ..... | Liverpool .....   | Prof. T. H. Huxley, LL.D., F.R.S. ....    | 314              | 39               |
| 1871, Aug. 2 .....   | Edinburgh .....   | Prof. Sir W. Thomson, LL.D., F.R.S.       | 246              | 28               |
| 1872, Aug. 14 .....  | Brighton .....    | Dr. W. B. Carpenter, F.R.S. ....          | 245              | 36               |
| 1873, Sept. 17 ..... | Bradford .....    | Prof. A. W. Williamson, F.R.S. ....       | 212              | 27               |
| 1874, Aug. 19 .....  | Belfast .....     | Prof. J. Tyndall, LL.D., F.R.S. ....      | 162              | 13               |
| 1875, Aug. 25 .....  | Bristol .....     | Sir John Hawkshaw, F.R.S. ....            | 239              | 36               |
| 1876, Sept. 6 .....  | Glasgow .....     | Prof. T. Andrews, M.D., F.R.S. ....       | 221              | 35               |
| 1877, Aug. 15 .....  | Plymouth .....    | Prof. A. Thomson, M.D., F.R.S. ....       | 173              | 19               |
| 1878, Aug. 14 .....  | Dublin .....      | W. Spottiswoode, M.A., F.R.S. ....        | 201              | 18               |
| 1879, Aug. 20 .....  | Sheffield .....   | Prof. G. J. Allman, M.D., F.R.S. ....     | 184              | 16               |
| 1880, Aug. 25 .....  | Swansea .....     | A. C. Ramsay, LL.D., F.R.S. ....          | 144              | 11               |
| 1881, Aug. 31 .....  | York .....        | Sir John Lubbock, Bart., F.R.S. ....      | 272              | 28               |
| 1882, Aug. 23 .....  | Southampton ..... | Dr. C. W. Siemens, F.R.S. ....            | 178              | 17               |
| 1883, Sept. 19 ..... | Southport .....   | Prof. A. Cayley, D.C.L., F.R.S. ....      | 203              | 60               |
| 1884, Aug. 27 .....  | Montreal .....    | Prof. Lord Rayleigh, F.R.S. ....          | 235              | 20               |
| 1885, Sept. 9 .....  | Aberdeen .....    | Sir Lyon Playfair, K.C.B., F.R.S. ...     | 225              | 18               |
| 1886, Sept. 1 .....  | Birmingham .....  | Sir J. W. Dawson, C.M.G., F.R.S. ...      | 314              | 25               |
| 1887, Aug. 31 .....  | Manchester .....  | Sir H. E. Roscoe, D.C.L., F.R.S. ....     | 428              | 86               |
| 1888, Sept. 5 .....  | Bath .....        | Sir F. J. Bramwell, F.R.S. ....           | 266              | 36               |
| 1889, Sept. 11 ..... | Newcastle-on-Tyne | Prof. W. H. Flower, C.B., F.R.S. ....     | 277              | 20               |
| 1890, Sept. 3 .....  | Leeds .....       | Sir F. A. Abel, C.B., F.R.S. ....         | 259              | 21               |
| 1891, Aug. 19 .....  | Cardiff .....     | Dr. W. Huggins, F.R.S. ....               | 189              | 24               |
| 1892, Aug. 3 .....   | Edinburgh .....   | Sir A. Geikie, LL.D., F.R.S. ....         | 280              | 14               |
| 1893, Sept. 13 ..... | Nottingham .....  | Prof. J. S. Burdon Sanderson, F.R.S.      | 201              | 17               |
| 1894, Aug. 8 .....   | Oxford .....      | The Marquis of Salisbury, K.G., F.R.S.    | 327              | 21               |
| 1895, Sept. 11 ..... | Ipswich .....     | Sir Douglas Galton, K.C.B., F.R.S. ...    | 214              | 13               |
| 1896, Sept. 16 ..... | Liverpool .....   | Sir Joseph Lister, Bart., Pres. R.S. ...  | 330              | 31               |
| 1897, Aug. 18 .....  | Toronto .....     | Sir John Evans, K.C.B., F.R.S. ....       | 120              | 8                |
| 1898, Sept. 7 .....  | Bristol .....     | Sir W. Crookes, F.R.S. ....               | 281              | 19               |
| 1899, Sept. 13 ..... | Dover .....       | Sir Michael Foster, K.C.B., Sec. R.S. ... | 296              | 20               |

\* Ladies were not admitted by purchased tickets until 1843. † Tickets of Admission to Sections only.

[Continued on p. xxvi.]

## ANNUAL MEETINGS.

| Old Annual Members | New Annual Members | Associates | Ladies | Foreigners   | Total | Amount received for Tickets | Sums paid on account of Grants for Scientific Purposes | Year |
|--------------------|--------------------|------------|--------|--------------|-------|-----------------------------|--|------|
| —                  | —                  | —          | —      | —            | 353   | —                           | —  | 1831 |
| —                  | —                  | —          | —      | —            | —     | —                           | —  | 1832 |
| —                  | —                  | —          | —      | —            | 900   | —                           | —  | 1833 |
| —                  | —                  | —          | —      | —            | 1298  | —                           | £20 0 0  | 1834 |
| —                  | —                  | —          | —      | —            | —     | —                           | 167 0 0  | 1835 |
| —                  | —                  | —          | —      | —            | 1350  | —                           | 435 0 0  | 1836 |
| —                  | —                  | —          | —      | —            | 1840  | —                           | 922 12 6   | 1837 |
| —                  | —                  | —          | 1110*  | —            | 2400  | —                           | 932 2 2  | 1838 |
| —                  | —                  | —          | —      | 34           | 1438  | —                           | 1595 11 0  | 1839 |
| —                  | —                  | —          | —      | 40           | 1353  | —                           | 1546 16 4  | 1840 |
| —                  | —                  | —          | —      | —            | 891   | —                           | 1235 10 11   | 1841 |
| 46                 | 317                | —          | 60*    | —            | 1079  | —                           | 1449 17 8  | 1842 |
| 75                 | 376                | 33†        | 331*   | 28           | 1315  | —                           | 1565 10 2  | 1843 |
| 71                 | 185                | —          | 160    | —            | —     | —                           | 981 12 8   | 1844 |
| 45                 | 190                | 9†         | 260    | —            | —     | —                           | 831 9 9  | 1845 |
| 94                 | 22                 | 407        | 172    | 35           | 857   | —                           | 685 16 0   | 1846 |
| 65                 | 39                 | 270        | 196    | 36           | 1320  | —                           | 208 5 4  | 1847 |
| 197                | 40                 | 495        | 203    | 53           | 819   | £707 0 0                    | 275 1 8  | 1848 |
| 54                 | 25                 | 376        | 197    | 15           | 1071  | 963 0 0                     | 159 19 6   | 1849 |
| 93                 | 33                 | 447        | 237    | 22           | 1241  | 1085 0 0                    | 345 18 0   | 1850 |
| 128                | 42                 | 510        | 273    | 44           | 710   | 620 0 0                     | 391 9 7  | 1851 |
| 61                 | 47                 | 244        | 141    | 37           | 1108  | 1085 0 0                    | 304 6 7  | 1852 |
| 63                 | 60                 | 510        | 292    | 9            | 876   | 903 0 0                     | 205 0 0  | 1853 |
| 56                 | 57                 | 367        | 236    | 6            | 1802  | 1882 0 0                    | 380 19 7   | 1854 |
| 121                | 121                | 765        | 524    | 10           | 2133  | 2311 0 0                    | 480 16 4   | 1855 |
| 142                | 101                | 1094       | 543    | 26           | 1115  | 1098 0 0                    | 734 13 9   | 1856 |
| 104                | 48                 | 412        | 366    | 9            | 2022  | 2015 0 0                    | 507 15 4   | 1857 |
| 156                | 120                | 900        | 569    | 26           | 1698  | 1931 0 0                    | 618 18 2   | 1858 |
| 111                | 91                 | 710        | 509    | 13           | 2564  | 2782 0 0                    | 684 11 1   | 1859 |
| 125                | 179                | 1206       | 821    | 22           | 1689  | 1604 0 0                    | 766 19 6   | 1860 |
| 177                | 59                 | 636        | 463    | 47           | 3138  | 3944 0 0                    | 1111 5 10  | 1861 |
| 184                | 125                | 1589       | 791    | 15           | 1161  | 1089 0 0                    | 1293 16 6  | 1862 |
| 150                | 57                 | 433        | 242    | 25           | 3335  | 3640 0 0                    | 1608 3 10  | 1863 |
| 154                | 209                | 1704       | 1004   | 25           | 2802  | 2965 0 0                    | 1289 15 8  | 1864 |
| 182                | 103                | 1119       | 1058   | 13           | 1997  | 2227 0 0                    | 1591 7 10  | 1865 |
| 215                | 149                | 766        | 508    | 23           | 2303  | 2469 0 0                    | 1750 13 4  | 1866 |
| 218                | 105                | 960        | 771    | 11           | 2444  | 2613 0 0                    | 1739 4 0   | 1867 |
| 193                | 118                | 1163       | 771    | 7            | 2004  | 2042 0 0                    | 1940 0 0   | 1868 |
| 226                | 117                | 720        | 682    | 45‡          | 1856  | 1931 0 0                    | 1622 0 0   | 1869 |
| 229                | 107                | 678        | 600    | 17           | 2878  | 3096 0 0                    | 1572 0 0   | 1870 |
| 303                | 195                | 1103       | 910    | 14           | 2463  | 2575 0 0                    | 1472 2 6   | 1871 |
| 311                | 127                | 976        | 754    | 21           | 2533  | 2649 0 0                    | 1285 0 0   | 1872 |
| 280                | 80                 | 937        | 912    | 43           | 1983  | 2120 0 0                    | 1685 0 0   | 1873 |
| 237                | 99                 | 796        | 601    | 11           | 1951  | 1979 0 0                    | 1151 16 0  | 1874 |
| 232                | 85                 | 817        | 630    | 12           | 2248  | 2397 0 0                    | 960 0 0  | 1875 |
| 307                | 93                 | 884        | 672    | 17           | 2774  | 3023 0 0                    | 1092 4 2   | 1876 |
| 331                | 185                | 1265       | 712    | 25           | 1229  | 1268 0 0                    | 1128 9 7   | 1877 |
| 238                | 59                 | 446        | 283    | 11           | 2578  | 2615 0 0                    | 725 16 6   | 1878 |
| 290                | 93                 | 1285       | 674    | 17           | 1404  | 1425 0 0                    | 1080 11 11   | 1879 |
| 239                | 74                 | 529        | 349    | 13           | 915   | 899 0 0                     | 731 7 7  | 1880 |
| 171                | 41                 | 389        | 147    | 12           | 2557  | 2689 0 0                    | 476 8 1  | 1881 |
| 313                | 176                | 1230       | 514    | 24           | 1253  | 1286 0 0                    | 1126 1 11  | 1882 |
| 253                | 79                 | 516        | 189    | 21           | 2714  | 3369 0 0                    | 1083 3 3   | 1883 |
| 330                | 323                | 952        | 841    | 5            | 1777  | 1855 0 0                    | 1173 4 0   | 1884 |
| 317                | 219                | 826        | 74     | 26 & 60 H. § | 2203  | 2256 0 0                    | 1385 0 0   | 1885 |
| 332                | 122                | 1053       | 447    | 6            | 2453  | 2532 0 0                    | 995 0 6  | 1886 |
| 428                | 179                | 1067       | 429    | 11           | 3838  | 4336 0 0                    | 1186 18 0  | 1887 |
| 510                | 244                | 1985       | 493    | 92           | 1984  | 2107 0 0                    | 1511 0 5   | 1888 |
| 399                | 100                | 639        | 509    | 12           | 2437  | 2441 0 0                    | 1417 0 11  | 1889 |
| 412                | 113                | 1024       | 579    | 21           | 1775  | 1776 0 0                    | 789 16 8   | 1890 |
| 368                | 92                 | 680        | 334    | 12           | 1497  | 1664 0 0                    | 1029 10 0  | 1891 |
| 341                | 152                | 672        | 107    | 35           | 2070  | 2007 0 0                    | 864 10 0   | 1892 |
| 413                | 141                | 733        | 439    | 50           | 1661  | 1653 0 0                    | 907 15 6   | 1893 |
| 328                | 57                 | 773        | 268    | 17           | 2321  | 2175 0 0                    | 583 15 6   | 1894 |
| 435                | 69                 | 941        | 451    | 77           | 1324  | 1236 0 0                    | 977 15 5   | 1895 |
| 290                | 31                 | 493        | 261    | 22           | 3181  | 3228 0 0                    | 1104 6 1   | 1896 |
| 383                | 139                | 1384       | 873    | 41           | 1362  | 1398 0 0                    | 1059 10 8  | 1897 |
| 286                | 125                | 682        | 100    | 41           | 2446  | 2399 0 0                    | 1212 0 0   | 1898 |
| 327                | 96                 | 1051       | 639    | 33           | 1403  | 1328 0 0                    | 1430 14 2  | 1899 |
| 324                | 68                 | 548        | 120    | 27           |       |                             |  |      |

‡ Including Ladies. § Fellows of the American Association were admitted as Hon. Members for this Meeting.

[Continued on p. xxvii.]



| Date of Meeting       | Where held              | Presidents  | Old Life Members | New Life Members |
|-----------------------|-------------------------|---|------------------|------------------|
| 1900, Sept. 5 .....   | Bradford .....          | Sir William Turner, D.C.L., F.R.S. ....                   | 267              | 13               |
| 1901, Sept. 11.....   | Glasgow .....           | Prof. A. W. Rücker, D.Sc., Sec. R.S. ....                 | 310              | 37               |
| 1902, Sept. 10.....   | Belfast .....           | Prof. J. Dewar, LL.D., F.R.S. ....                        | 243              | 21               |
| 1903, Sept. 9 .....   | Southport .....         | Sir Norman Lockyer, K.C.B., F.R.S. ....                   | 250              | 21               |
| 1904, Aug. 17 .....   | Cambridge .....         | Rt. Hon. A. J. Balfour, M.P., F.R.S. ....                 | 419              | 32               |
| 1905, Aug. 15 .....   | South Africa .....      | Prof. G. H. Darwin, LL.D., F.R.S. ....                    | 115              | 40               |
| 1906, Aug. 1 .....    | York .....              | Prof. E. Ray Lankester, LL.D., F.R.S. ....                | 322              | 10               |
| 1907, July 31 .....   | Leicester .....         | Sir David Gill, K.C.B., F.R.S. ....                       | 276              | 19               |
| 1908, Sept. 2 .....   | Dublin .....            | Dr. Francis Darwin, F.R.S. ....                           | 294              | 24               |
| 1909, Aug. 25 .....   | Winnipeg .....          | Prof. Sir J. J. Thomson, F.R.S. ....                      | 117              | 13               |
| 1910, Aug. 31 .....   | Sheffield .....         | Rev. Prof. T. G. Bonney, F.R.S. ....                      | 293              | 26               |
| 1911, Aug. 30 .....   | Portsmouth .....        | Prof. Sir W. Ramsay, K.C.B., F.R.S. ....                  | 284              | 21               |
| 1912, Sept. 4 .....   | Dundee .....            | Prof. E. A. Schäfer, F.R.S. ....                          | 288              | 14               |
| 1913, Sept. 10 .....  | Birmingham .....        | Sir Oliver J. Lodge, F.R.S. ....                          | 376              | 40               |
| 1914, July-Sept. .... | Australia .....         | Prof. W. Bateson, F.R.S. ....                             | 172              | 13               |
| 1915, Sept. 7 .....   | Manchester .....        | Prof. A. Schuster, F.R.S. ....                            | 242              | 19               |
| 1916, Sept. 5 .....   | Newcastle-on-Tyne ..... | Sir Arthur Evans, F.R.S. ....                             | 164              | 12               |
| 1917 .....            | (No Meeting) .....      |   | —                | —                |
| 1918 .....            | (No Meeting) .....      |   | —                | —                |
| 1919, Sept. 9 .....   | Bournemouth.....        | Hon. Sir C. Parsons, K.C.B., F.R.S. ....                  | 235              | 47               |
|                       |                         |   |                  |                  |
| 1920, Aug. 24 .....   | Cardiff .....           | Prof. W. A. Herdman, C.B.E., F.R.S. ....                  | 288              | 11               |
| 1921, Sept. 7 .....   | Edinburgh .....         | Sir T. E. Thorpe, C.B., F.R.S. ....                       | 336              | 9                |
| 1922, Sept. 6 .....   | Hull .....              | Sir C. S. Sherrington, G.B.E., Pres. R.S. ....            | 228              | 13               |
|                       |                         |   |                  |                  |
| 1923, Sept. 12.....   | Liverpool .....         | Sir Ernest Rutherford, F.R.S. ....                        | 326              | 12               |
| 1924, Aug. 6 .....    | Toronto .....           | Sir David Bruce, K.C.B., F.R.S. ....                      | 119              | 7                |
| 1925, Aug. 26 .....   | Southampton .....       | Prof. Horace Lamb, F.R.S. ....                            | 280              | 8                |
| 1926, Aug. 4 .....    | Oxford .....            | H.R.H. The Prince of Wales, K.G.,<br>F.R.S. ....          | 358              | 9                |
| 1927, Aug. 31 .....   | Leeds .....             | Sir Arthur Keith, F.R.S. ....                             | 249              | 9                |
| 1928, Sept. 5 .....   | Glasgow .....           | Sir William Bragg, K.B.E., F.R.S. ....                    | 260              | 10               |
| 1929, July 22 .....   | South Africa .....      | Sir Thomas Holland, K.C.S.I.,<br>K.C.I.E., F.R.S. ....    | 81               | 1                |
| 1930, Sept. 3 .....   | Bristol .....           | Prof. F. O. Bower, F.R.S. ....                            | 221              | 5                |
| 1931, Sept. 23.....   | London .....            | Gen. the Rt. Hon. J. C. Smuts, P.C.,<br>C.H., F.R.S. .... | 487              | 14               |
| 1932, Aug. 31 .....   | York .....              | Sir Alfred Ewing, K.C.B., F.R.S. ....                     | 206              | 1                |
| 1933, Sept. 6 .....   | Leicester .....         | Sir F. Gowland Hopkins, Pres. R.S. ....                   | 185              | 37               |
| 1934, Sept. 5 .....   | Aberdeen .....          | Sir James H. Jeans, F.R.S. <sup>14</sup> .....            | 199              | 21               |
| 1935, Sept. 4 .....   | Norwich .....           | Prof. W. W. Watts, F.R.S. ....                            | 191              | 11               |
| 1936, Sept. 9 .....   | Blackpool .....         | Sir Josiah Stamp, G.C.B., G.B.E. ....                     | 188              | 10               |

<sup>1</sup> Including 848 Members of the South African Association.<sup>2</sup> Including 137 Members of the American Association.<sup>3</sup> Special arrangements were made for Members and Associates joining locally in Australia, see Report, 1914, p. 686. The numbers include 80 Members who joined in order to attend the Meeting of L'Association Française at Le Havre.<sup>4</sup> Including Students' Tickets, 10s.<sup>5</sup> Including Exhibitioners granted tickets without charge.<sup>6</sup> Including grants from the Caird Fund in this and subsequent years.<sup>7</sup> Including Foreign Guests, Exhibitioners, and others.

*Annual Meetings—(continued).*

| Old Annual Members | New Annual Members | Associates       | Ladies | Foreigners | Total             | Amount received for Tickets | Sums paid on account of Grants for Scientific Purposes | Year |
|--------------------|--------------------|------------------|--------|------------|-------------------|-----------------------------|--|------|
| 297                | 45                 | 801              | 482    | 9          | 1915              | £1801 0 0                   | £1072 10 0   | 1900 |
| 374                | 131                | 794              | 246    | 20         | 1912              | 2046 0 0                    | 920 9 11   | 1901 |
| 314                | 86                 | 647              | 305    | 6          | 1620              | 1644 0 0                    | 947 0 0  | 1902 |
| 319                | 90                 | 688              | 365    | 21         | 1754              | 1762 0 0                    | 845 13 2   | 1903 |
| 449                | 113                | 1338             | 317    | 121        | 2789              | 2650 0 0                    | 887 18 11  | 1904 |
| 937 <sup>1</sup>   | 411                | 430              | 181    | 16         | 2130              | 2422 0 0                    | 928 2 2  | 1905 |
| 356                | 93                 | 817              | 352    | 22         | 1972              | 1811 0 0                    | 882 0 9  | 1906 |
| 339                | 61                 | 659              | 251    | 42         | 1647              | 1561 0 0                    | 757 12 10  | 1907 |
| 465                | 112                | 1166             | 222    | 14         | 2297              | 2317 0 0                    | 1157 18 8  | 1908 |
| 290 <sup>3</sup>   | 162                | 789              | 90     | 7          | 1468              | 1623 0 0                    | 1014 9 9   | 1909 |
| 379                | 57                 | 563              | 123    | 8          | 1449              | 1439 0 0                    | 963 17 0   | 1910 |
| 349                | 61                 | 414              | 81     | 31         | 1241              | 1176 0 0                    | 922 0 0  | 1911 |
| 368                | 95                 | 1292             | 359    | 88         | 2504              | 2349 0 0                    | 845 7 6  | 1912 |
| 480                | 149                | 1287             | 291    | 20         | 2643              | 2756 0 0                    | 978 17 1   | 1913 |
| 139                | 4160 <sup>3</sup>  | 539 <sup>3</sup> | —      | 21         | 5044 <sup>3</sup> | 4873 0 0                    | 1861 16 4 <sup>8</sup>                                 | 1914 |
| 287                | 116                | 628 <sup>4</sup> | 141    | 8          | 1441              | 1406 0 0                    | 1569 2 8   | 1915 |
| 250                | 76                 | 251 <sup>4</sup> | 73     | —          | 826               | 821 0 0                     | 985 18 10  | 1916 |
| —                  | —                  | —                | —      | —          | —                 | —                           | 677 17 2   | 1917 |
| —                  | —                  | —                | —      | —          | —                 | —                           | 326 13 3   | 1918 |
| 254                | 102                | 688 <sup>4</sup> | 153    | 3          | 1482              | 1736 0 0                    | 410 0 0  | 1919 |

| Old Annual Regular Members | Annual Members     |                    | Transferable Tickets | Students' Tickets |                            |                    |                         |                         |      |
|----------------------------|--------------------|--------------------|----------------------|-------------------|----------------------------|--------------------|-------------------------|-------------------------|------|
|                            | Meeting and Report | Meeting only       |                      |                   |                            |                    |                         |                         |      |
| 136                        | 192                | 571                | 42                   | 120               | 20                         | 1380               | 1272 10 0               | 1251 13 0 <sup>8</sup>  | 1920 |
| 133                        | 410                | 1394               | 121                  | 343               | 22                         | 2768               | 2599 15 0               | 518 1 10                | 1921 |
| 90                         | 294                | 757                | 89                   | 235 <sup>5</sup>  | 24                         | 1730               | 1699 5 0                | 722 0 7                 | 1922 |
|                            |                    |                    |                      |                   | Complimentary <sup>7</sup> |                    |                         |                         |      |
| 123                        | 380                | 1434               | 163                  | 550               | 308                        | 3296               | 2735 15 0               | 777 18 6 <sup>9</sup>   | 1923 |
| 37                         | 520                | 1866               | 41                   | 89                | 139                        | 2818               | 3165 19 0 <sup>10</sup> | 1197 5 9                | 1924 |
| 97                         | 264                | 878                | 62                   | 119               | 74                         | 1782               | 1630 5 0                | 1231 0 0                | 1925 |
| 101                        | 453                | 2338               | 169                  | 225               | 69                         | 3722               | 3542 0 0                | 917 1 6                 | 1926 |
| 84                         | 334                | 1487               | 82                   | 264               | 161                        | 2670               | 2414 5 0                | 761 10 0                | 1927 |
| 76                         | 554                | 1835               | 64                   | 201               | 74                         | 3074               | 3072 10 0               | 1259 10 0               | 1928 |
| 24                         | 177                | 1227 <sup>11</sup> | —                    | 161               | 83                         | 1754               | 1477 15 0               | 2193 2 1                | 1929 |
| 68                         | 310                | 1617               | 97                   | 267               | 54                         | 2639               | 2481 15 0               | 631 1 9                 | 1930 |
| 78                         | 656                | 2994               | 157                  | 454               | 449                        | 5702 <sup>12</sup> | 4792 10 0               | 1319 9 6                | 1931 |
| 44                         | 226                | 1163               | 45                   | 214               | 125                        | 2024               | 1724 5 0                | 1218 13 11              | 1932 |
| 39                         | 236                | 1468               | 82                   | 147               | 74                         | 2268               | 2428 2 0                | 562 19 11 <sup>13</sup> | 1933 |
| 30                         | 273                | 1884               | 181                  | 280               | 70                         | 2938               | 2900 13 6               | 1423 4 9                | 1934 |
| 29                         | 237                | 1444               | 142                  | 197               | 70                         | 2321               | 2218 14 6               | 1649 2 4                | 1935 |
| 29                         | 257                | 1184               | 128                  | 178               | 93                         | 2067               | 2006 14 0               | 1098 1 1                | 1936 |

<sup>6</sup> The Bournemouth Fund for Research, initiated by Sir C. Parsons, enabled grants on account of scientific purposes to be maintained.

<sup>9</sup> Including grants from the Caird Gift for research in radioactivity in this and subsequent years to 1926.

<sup>10</sup> Subscriptions paid in Canada were \$5 for Meeting only and others pro rata; there was some gain on exchange.

<sup>11</sup> Including 450 Members of the South African Association.

<sup>12</sup> Including 413 tickets for certain meetings, issued at 5s. to London County Council school-teachers.

<sup>13</sup> For nine months ending March 31, 1933.

<sup>14</sup> Sir William B. Hardy, F.R.S., who became President on January 1, 1934, died on January 23.

## NARRATIVE OF THE BLACKPOOL MEETING

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ON Wednesday, September 9, at 8.30 P.M., the Inaugural General Meeting was held in the Empress Ballroom, Winter Gardens, when His Worship the Mayor of Blackpool (Alderman W. Newman, J.P.) welcomed the Association to Blackpool. The President of the Association, Sir Josiah Stamp, G.C.B., G.B.E., delivered an address (for which see p. 1) entitled *The Impact of Science upon Society*. A vote of thanks to the President was proposed by Sir Oliver Lodge, F.R.S., and seconded by Prof. E. G. Conklin, President of the American Association for the Advancement of Science.

On Friday, September 11, in the Co-operative Hall, at 8.15 P.M., Mr. C. C. Paterson, O.B.E., delivered an Evening Discourse on *Science and Electric Lighting*, for which see p. 478.

On Tuesday, September 15, in the same hall, at 8.15 P.M., Capt. F. Kingdon Ward delivered an Evening Discourse on *Plant-hunting and Exploration in Tibet*.

A public lecture was given by Dr. W. F. Bewley on *Science and the Glasshouse Industry*, in Marton Parochial Hall, Blackpool, on Friday, September 11, at 7.30 P.M.

Lectures to school children were given in Blackpool as follows :

Brigadier H. S. L. Winterbotham, C.B., C.M.G., D.S.O. : *How Maps are made*, on Friday, September 11, at 3 P.M., in the New Technical College, Palatine Road.

Mr. D. Seth Smith : *Favourites of the London Zoo*, on Tuesday, September 15, at 3 P.M., in the Co-operative Hall.

External public lectures were given as follows :

Lytham St. Annes, Lowther Pavilion, Thursday, September 10, at 7.30 P.M. *The Scope of Photography*.—Dr. Olaf Bloch.

Preston, Guild Hall, Friday, September 11, at 8.0 P.M. *Who were the Greeks?*—Prof. J. L. Myres.

Southport, Cambridge Hall, Lord Street, Friday, September 11, at 8.0 P.M. *Some Recent Advances in Astronomy*.—Sir James Jeans, F.R.S.

Poulton-le-Fylde, Church Hall, Vicarage Road, Monday, September 14, at 7.30 P.M. *Applications of Science to Poultry Farming*.—Mr. P. A. Francis.

Fleetwood, Marine Hall, Tuesday, September 15, at 7.30 P.M. *Common Shore Animals*.—Prof. C. M. Yonge.



Thornton Cleveleys, St. Andrew's Memorial Hall, Tuesday, September 15, at 7.30 P.M. *Joy in Scientific Discovery*.—Prof. D. Fraser-Harris.

Preston, Guild Hall, Wednesday, September 16, at 8.0 P.M. *Splashes and what they teach*.—Prof. Allan Ferguson.

Rochdale. The above lecture by Prof. Allan Ferguson was repeated at Rochdale on Thursday, September 17.

A summary of Sectional Transactions on September 10, 11, 14, 15, and 16 will be found on pp. 320 and following.

\* \* \* \* \*

The Mayor and Mayoress of Blackpool (Alderman W. Newman, J.P., and Miss Newman) entertained members of the Association at a Reception and Dance in the Empress Ballroom, Winter Gardens, on Thursday evening, September 10.

A Garden Party was given by the Headmaster of Rossall School (Mr. H. G. M. Clarke) at the School on Tuesday, September 15.

\* \* \* \* \*

On Saturday, September 12, a general excursion was arranged to the Lake District, when a number of the members travelled as guests of the President, Sir Josiah Stamp, G.C.B., G.B.E., Chairman of the London, Midland and Scottish Railway. During the return journey the President broadcast from the train at Oxenholme station to Blackpool a speech inaugurating the autumn illuminations. Other excursions and visits devoted to the interests of special sections are mentioned among the Sectional Transactions in later pages.

\* \* \* \* \*

A special service was held at St. John's Parish Church on Sunday morning, September 13, when officers and other members of the Association accompanied the Mayor and Corporation in state. The preacher was the Rt. Rev. P. M. Herbert, Lord Bishop of Blackburn. Special services were also held in other places of worship.

\* \* \* \* \*

At the final meeting of the General Committee, on Wednesday, September 16, it was resolved :

That the British Association places on record its warm thanks for the reception afforded to it by the County Borough of Blackpool. The generous co-operation of the Mayor and Council, and the thorough preparations made by the local officers and committee, have been deeply appreciated. The Association also extends most cordial thanks to the commercial, industrial, and educational institutions in Blackpool and the neighbourhood, which have so generously provided accommodation and facilities for meetings, excursions, and visits. The Association, having broken new ground in this, its one-hundred-and-sixth year, with a first meeting in Blackpool, records with special satisfaction the unqualified success of this meeting.

## VISIT TO THE ISLE OF MAN.

After the meeting, a number of members took part in a visit to the Isle of Man (September 16-21), by invitation of the island authorities. Parties were conducted each day to sites of archæological, geological, biological, and botanical interest in various parts of the island. The visitors were received on successive evenings (Sept. 17, 18, 19) by His Honour the Deemster Farrant, Chairman of the Manx Museum and Ancient Monuments Trustees (when H.E. the Lieutenant-Governor, Sir Montagu Butler, K.C.S.I., and Lady Butler were present), by His Worship the Mayor and Corporation of Douglas, and by the Manx Museum and Ancient Monuments Trustees.

The Council subsequently conveyed their thanks and those of the visitors to the island authorities concerned.

# REPORT OF THE COUNCIL, 1935-36.

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DEATH OF H.M. KING GEORGE V, PATRON OF THE ASSOCIATION.

I.—The following Address was forwarded to His Majesty King Edward VIII :—

*To the King's Most Excellent Majesty.*

*May it please Your Majesty,*

We, Your Majesty's most dutiful and loyal subjects, the President and Council of the British Association for the Advancement of Science, humbly beg leave to offer to Your Majesty our deep and heartfelt sympathy in the grievous loss that has befallen Your Majesty, the Members of Your Royal Family and the British peoples. We of the British Association deplore the loss of a Sovereign who has ever encouraged us in the advancement of Science and the rightful application of scientific knowledge to the enlargement of the happiness of His peoples ; and has honoured the Association by becoming its Patron and by conferring upon the Association the high privilege of its Royal Charter.

While thus expressing our grief, we most humbly beg leave to offer to Your Majesty our congratulations on Your Majesty's accession to the Throne, and we earnestly pray that Your Majesty may long reign over Your peoples throughout the Empire.

The following acknowledgment was received by the President :—

HOME OFFICE,  
WHITEHALL.

17th March, 1936.

SIR,—I have had the honour to lay before The King the Loyal and Dutiful Address of the President and Council of the British Association for the Advancement of Science on the occasion of the lamented death of His late Majesty King George the Fifth, and have received The King's Command to convey to you His Majesty's grateful Thanks for the assurances of sympathy and devotion to which it gives expression.

I am, Sir,

Your obedient Servant,

JOHN SIMON.

## THE ROYAL PATRONAGE.

II.—The President, on behalf of the Council, forwarded the following letter :—

To the Private Secretary  
to His Majesty The King

SIR,—I have the honour to inform you that the Council of the British Association for the Advancement of Science have voted a humble address of condolence to His Majesty The King.



The address refers gratefully to the honour which King George V conferred upon the Association by becoming its Patron. The Council, in voting the Address, directed me to express the respectful hope that His Majesty may be graciously pleased to follow his august Father in the Patronage of the Association. We are ever mindful of the signal honour which His Majesty conferred upon the Association by becoming its President for the year 1926.

I have the honour to be, Sir,  
Your obedient Servant,  
J. C. STAMP,  
*President.*

The following reply was received :—

PRIVY PURSE OFFICE,  
BUCKINGHAM PALACE, S.W.  
23rd March, 1936.

DEAR SIR,—I am commanded by The King to inform you that His Majesty has been graciously pleased to grant his Patronage to the British Association for the Advancement of Science.

Yours truly,  
WIGRAM,  
*Keeper of the Privy Purse.*

#### OBITUARY.

III.—The Council have had to deplore the loss by death of the following office-bearers and supporters :—

|   |  |
|---|--|
| Prof. J. H. Ashworth, F.R.S.            | Prof. P. F. Kendall, F.R.S.                  |
| Sir J. F. Beale, K.B.E.                 | Dr. W. J. S. Lockyer                         |
| Mr. F. A. Bellamy                       | Sir J. C. McLennan, K.B.E., F.R.S.           |
| Dr. H. Bolton                           | Prof. C. Lloyd Morgan, F.R.S.                |
| Prof. J. D. Cormack, C.M.G.,<br>C.B.E.  | Mr. R. D. Oldham, F.R.S.                     |
| Mr. G. F. Daniell                       | Prof. H. Fairfield Osborn, For.<br>Mem. R.S. |
| Sir A. Denny, Bt.                       | Prof. Karl Pearson, F.R.S.                   |
| Prof. A. C. Dixon, F.R.S.               | Sir J. E. Petavel, K.B.E., F.R.S.            |
| Prof. A. F. Dixon                       | Miss I. M. Roper                             |
| Dr. R. V. Favell                        | Dr. F. C. Shrubbsall                         |
| Prof. H. S. Foxwell                     | Mrs. Henry Sidgwick                          |
| Miss Marion Frost                       | Dr. Bernard Smith, F.R.S.                    |
| Sir R. T. Glazebrook, K.C.B.,<br>F.R.S. | Miss Grace Stebbing                          |
| Prof. J. S. Haldane, F.R.S.             | Prof. J. E. A. Steggall                      |

#### REPRESENTATION.

IV.—Representatives of the Association have been appointed as follows :—

Centenary Celebration of the University of  
London, June 29-July 3 . . . Sir Josiah Stamp,  
G.C.B., G.B.E.,  
President.

Quinquennial Congress of Universities of  
the Empire, Cambridge, July 13-17

Mr. F. T. Brooks,  
F.R.S., General Sec-  
retary.

### RESOLUTIONS AND RECOMMENDATIONS.

V.—Resolutions and recommendations, referred by the General Committee to the Council for consideration, and, if desirable, for action, were dealt with as follows. The resolutions will be found in the *Report* for 1935, p. xlvii.

(a) The Council, on learning that the late Prof. J. H. Ashworth, F.R.S., had presented a fuller version of his paper on the life of Charles Darwin as a student in Edinburgh to the Royal Society of Edinburgh, procured reprints for preservation at Down House and for distribution as requisite. (Resolution of the General Committee.)

(b) The Council appointed a watching committee to co-operate, as occasion should arise, with the Ministry of Health Committee on Inland Water Survey. (Resolution of Sections A, Mathematical and Physical Sciences ; C, Geology ; E, Geography ; G, Engineering.)

(c) The Council communicated to the Ministry of Transport the resolution on the silencing of motor vehicles recommended by Sections A (Mathematical and Physical Sciences) and G (Engineering), excepting the concluding paragraph.

(d) The Council appointed a committee, and invited representatives thereon from other institutions, to consider what steps could be taken, in co-operation with similar bodies in other countries, to assist in giving effect to the legislation of the Government of Ecuador relating to the preservation of the fauna of the Galapagos Islands. (Resolution of Section D, Zoology.)

In connection with the above, Prof. W. W. Watts, F.R.S. (President, 1935), communicated to the Council a cablegram received from the present H.M.S. *Beagle* on the day of the centenary of Darwin's landing from the vessel of that name in the Galapagos Islands. The cablegram was in the following terms :—

To-day one hundred years ago our most distinguished passenger landed. The present *Beagle* salutes the British Association the Trustees of Science.

The President stated that he had forwarded a reply as follows :—

Deeply appreciate your message referring Darwin's landing from *Beagle*. Good luck to present ship.

(e) After consideration of the recommendation of Section F (Economics), supported by Section J (Psychology), that the Association might indicate the importance which it attaches to the development of the social sciences by appointing a third General Secretary, who would be specially associated with this group of studies, the Council resolved to appoint a committee to consider how the Association might indicate

the importance which it attaches to the development of the social sciences, either by appointment of a third General Secretary or by other appropriate means.

On the report of this committee, it was resolved that the appointment of a third General Secretary should not be recommended to the General Committee, but effect has been given to the following recommendations, with the collaboration of the Organising Sectional Committees :—

That certain selected communications in the programme at the Annual Meeting should be distinguished, by inclusion in a separate group with a collective series-title or other appropriate means, as of special bearing upon the relations between Science and the interests of the community. Under this proposal :

(a) An Organising Sectional Committee might request that any discussion or individual paper might be included in this series.

(b) A Sectional President might request that his address should be included in this series.

(c) It is submitted that the Council should arrange at least one of the Evening Discourses with a view to inclusion in this series.

The Committee believe that this procedure, without involving any violent reform of the programmes, would provide the evidence which public opinion demands that the Association does in fact discharge its function of 'obtaining a more general interest for the objects of Science.'

A further proposal made in the Council itself was that at least one discussion in each annual programme should deal with the application of science to social problems.

The above arrangements have been put into force in connection with the programme of the Blackpool Meeting.

(f) The specification of the lower yield-point of mild and moderately high tensile steel, recommended by Section G (Engineering), was communicated to the British Standards Institution.

(g) The recommendation of Section H (Anthropology) relating to the preservation of certain caves in Derbyshire was forwarded to H.M. Commissioner of Works, and it was understood that this question would be submitted to the Ancient Monuments Board.

(h) The Council for the Preservation of Rural England kindly promised to take into consideration the desirability of preventing hedge-cutting, etc., at such season as to interfere with nesting birds. It was subsequently stated that the matter had been brought before the County Councils Association, which, while sympathising with the objects of the recommendation, did not consider it practicable to make any proposal to County Councils, especially in view of the provisions of the Corn Production Acts (Repeal) Act, 1921, regarding the destruction of injurious weeds. The matter, however, was further mentioned at a recent meeting of county surveyors in London. (Recommendation of the Conference of Delegates of Corresponding Societies.)

(i) The Council requested the Corresponding Societies Committee and the appropriate Sectional Committees to specify, if possible,



particular areas which might be scheduled as national parks on grounds of special scientific interest. (Resolution of the Conference of Delegates of Corresponding Societies.)

(j) It was stated in the *Report* for 1935, p. xxi, that the Council brought to the notice of the Lord President of the Council and the Minister of Agriculture the desirability of accelerating the revision of large-scale maps of the Ordnance Survey. It was learned that the Chartered Surveyors' Institution was taking similar action, and that Institution was kept informed of the Council's action. It was understood that the matter was receiving the attention of the Minister and of H.M. Government. (Resolution of Section E, Geography, supported by other sections.)

A request from the Chartered Surveyors' Institution, for support of the proposals to be brought before the Ministry of Agriculture by the Institution in favour of the revision of large-scale Ordnance Survey maps, was considered, but it was resolved that, in view of the previous action taken by the Council in this connection, no further action was necessary. Subsequently the Departmental Committee on the Ordnance Survey invited observations from the Association on certain aspects of the revision, and the Council, with the generous help of Brigadier H. S. L. Winterbotham, C.B., C.M.G., D.S.O., took measures to obtain these from appropriate sources.

#### FINANCE.

VI.—The Council have received reports from the General Treasurer throughout the year. His account has been audited and is presented to the General Committee.

The Council have received with regret the resignation of Prof. A. L. Bowley as an hon. auditor, and have conveyed to him their thanks for his services.

VII.—A contributory superannuation scheme has been arranged on behalf of members of the office staff other than the Secretary, for whom such a scheme already exists.

VIII.—The legacy of £500 received under the will of the late Sir Alfred Ewing, K.C.B., F.R.S., past President, as stated in the *Report*, 1935, p. xxi, has been invested.

A donation of one hundred guineas was forwarded to the Association by the Local Committee for the Norwich Meeting, 1935, out of the surplus on the local fund. The thanks of the Council were conveyed to the Committee, and it was resolved that the sum should be used to meet grants to Committees dealing with subjects of special scientific interest in East Anglia, such as pre-history, ornithology, etc., as and when occasion should arise.

A sum of £900 has been received (in successive payments of £500 and £400) on account of the Herbert Spencer bequest. In respect of the first payment, the Council adopted a proposal, supported by the Down House Committee, that this sum (£500) should be earmarked to meet temporarily

IX.—The Council made the following grants from funds under their control :—

|   |     |
|---|-----|
| Committee on Seismology                 | 150 |
| „ „ Mathematical Tables                 | 150 |
| „ „ Zoological Record                   | 50  |
| „ „ Naples Table                        | 50  |
| „ „ Rods and Cones in Retinæ of Animals | 10  |

|  |    |
|--|----|
| Committee on Reptile-bearing Oölite of Stow-on-the-Wold . . . . .                                  | 30 |
| „ „ Critical Geological Sections : such part as the income<br>allows of a contingent grant of £40. |    |

|  |    |
|--|----|
| Committee on Routine Manual Factor in Mechanical Ability . . . . . | 30 |
| „ „ Chronology of the World Crisis . . . . .                       | 10 |
| „ „ Noise . . . . .  | 10 |
| „ „ Promotion of Educational Research . . . . .                    | 5  |

X.—In 1927-28 a proposal for the amalgamation of the British Science Guild and the British Association was before the Council and the General Committee of the Association. Certain conditions attached to the proposal did not fully commend themselves to either party; but the proposal was not rejected in principle, and it was recorded in the Report of the Council, as adopted by the General Committee in 1928, that 'further action by the Council of the British Science Guild is awaited.' Such action has now been taken, and the Council, after full inquiry and report by the General Officers, recommend the incorporation of the Guild into the Association under the conditions set out below. The General Officers take this opportunity of acknowledging the generous collaboration of Sir Richard Gregory and Sir Albert Howard throughout the negotiations.

The stated object of the British Science Guild is 'to promote the application of scientific method and results to social problems and public affairs.' The same object is implicit in those of the Association, and the programmes of its recent meetings have given evidence of a greater concern for these problems than was commonly exhibited in former years. It is believed that the proposed union of the two bodies would strengthen the Association in the discharge of its public functions, and it is suggested that, through the Committee proposed below, the Council might be assisted in keeping itself informed as to matters concerning the application of scientific method and results to social problems and public affairs.

The capital funds of the Guild, to which reference is made below, would be transferred to the Association after the discharge of certain liabilities.

The proposed conditions of incorporation of the Guild into the Association are as follows :—

1. That the Council of the British Association should be asked to appoint a Committee to be called the British Science Guild Committee.
2. That the British Science Guild Committee should consist of six members, of whom not more than three should be nominated initially by the British Science Guild, and three by the British Association.
3. That the last act of the Guild before winding-up should be to constitute the present members of its Council an Advisory Council to nominate the three members of the British Science Guild Committee of the British Association, representing the British Science Guild.
4. That the British Science Guild Committee should be a Committee of Council of the British Association, and should be entrusted with arrangements for lectures already initiated by the British Science Guild, and for any others of similar character which may be approved by the Council.
5. That the Norman Lockyer Lecture should be delivered annually, and should deal with the application of scientific method and results to social problems and public affairs.
6. That the Alexander Pedler Lecture should be offered annually to one of the Corresponding Societies of the British Association, or be delivered in some centre outside London.
7. That Life Fellows of the British Science Guild be offered Life Membership of the British Association without further payment, and that Life Members of the Guild should be invited to become Life Members of the Association on payment of the difference between the subscription to the Guild and to the Association.

(*Note.*—There were as at January 7, 1936, 62 life fellows of the Guild of whom 5 were honorary, and of whose addresses 6 were unknown. Eleven of these were life members of the Association and 7 were or had recently been annual members. There were 273 life members of the Guild, of whose addresses 60 were unknown; of these 45 were life members of the Association, and 23 were or had recently been annual members.)

8. That annual subscribers of the Guild should be invited to become annual subscribers of the Association.

(*Note.*—The annual subscribers of the Guild as at June 25, 1935, numbered 242.)

*Financial note.*—The market value of the capital funds of the Guild as at January 3, 1936, is £4,355. It is understood that inquiry is in progress as to any liability which, in the event of the proposed incorporation being effected, would or might fall upon these funds in respect of life members not desiring transfer, the Guild staff, etc. The Norman Lockyer and Alexander Pedler lectures carry fees (ten guineas each) and involve certain incidental expenditure. For the two lectures together, including fees but excluding the printing of the lectures and postage, the total expenditure in 1935 was £36.

It is further understood that if the incorporation is carried out, Lady Lockyer intends to bequeath the sum of £1,000 to the Association. Sir



Albert Howard intends to bequeath a like sum, for the purpose of endowing an annual lecture to young people at that centre at which the annual meeting of the Association is held.

PRESIDENT (1937), GENERAL OFFICERS, COUNCIL AND COMMITTEES.

XI.—The Council's nomination to the Presidency of the Association for the year 1937 (Nottingham Meeting) will be announced to the General Committee at the Blackpool Meeting.

XII.—*The General Officers* have been nominated by the Council as follows :—

*General Treasurer*, Prof. P. G. H. Boswell, F.R.S.

*General Secretaries*, Mr. F. T. Brooks, F.R.S., Prof. Allan Ferguson.

XIII. *Council*.—The retiring Ordinary Members of the Council are: Prof. J. Drever, Prof. W. T. Gordon, Prof. Dame Helen Gwynne-Vaughan, G.B.E., Dr. C. W. Kimmins, and Prof. A. M. Tyndall, F.R.S.

The Council have nominated as new members Dr. F. W. Aston, F.R.S., Prof. F. Debenham, and Mr. W. Campbell Smith ; leaving two vacancies to be filled by the General Committee without nomination by the Council.

The full list of Ordinary Members is as follows :—

Dr. F. W. Aston, F.R.S.

Prof. F. Aveling

Sir T. Hudson Beare

Rt. Hon Viscount Bledisloe, P.C.,

G.C.M.G., G.B.E.

Prof. F. Balfour-Browne

Prof. R. N. Rudmose Brown

Dr. W. T. Calman, C.B., F.R.S.

Sir Henry Dale, C.B.E., F.R.S.

Prof. F. Debenham

Prof. W. G. Fearnside, F.R.S.

Prof. R. B. Forrester

H. M. Hallsworth, C.B.E.

Dr. H. S. Harrison

Prof. A. V. Hill, O.B.E., Sec.R.S.

Prof. G. W. O. Howe

Dr. Julian Huxley

Prof. R. Robinson, F.R.S.

W. Campbell Smith

Dr. C. Tierney

Dr. W. W. Vaughan, M.V.O.

Dr. J. A. Venn

Prof. Sir Gilbert Walker, C.S.I., F.R.S.

Prof. F. E. Weiss, F.R.S.

XIV. *General Committee*.—The following have been admitted as members of the General Committee, mainly on the nomination of Organising Sectional Committees under Regulation 1 :—

Prof. T. Alty

Dr. T. H. Bennet-Clark

Prof. A. H. Cox

Mr. O. Davies

Mr. H. Dewey

Mr. A. T. J. Dollar

Prof. J. M. F. Drummond

Dr. W. L. H. Duckworth

Miss E. D. Earthy

Mrs. H. W. Elgee

Dr. R. V. Favell

Miss D. A. E. Garrod

Mr. K. H. Jackson

Dr. Murray Macgregor

Prof. J. H. J. Poole

Capt. R. S. Rattray, C.B.E.

Prof. R. W. Reid

Mrs. C. G. Seligman

Rev. E. W. Smith

Prof. H. H. Swinnerton

Dr. G. Taylor

Dr. F. S. Wallis

Mr. W. H. Wilcockson

Dr. S. Williams

Dr. W. B. Wright

XV. *Corresponding Societies Committee*.—The Council resolved to inquire into the status of the Conference of Delegates of Corresponding Societies, and appointed a committee to consider and report upon this. The committee made the following recommendations, which the Council adopted :—

(1) An active liaison between the Association and the Conference by the regular attendance of the General Officers at its meetings.

(2) A policy of mutual co-operation between the Conference and the Sections of the Association.

(3) Additional representation of the Conference on the Committee of Recommendations (i.e. by the President and one other member).

(4) The Corresponding Societies Committee to consist of the President and General Officers of the Association (as at present), together with not more than six of the Delegates to be nominated at the annual conference, one-third of whom (i.e. the delegate representatives) shall retire annually and shall not be eligible for immediate re-election.

It is assumed that the retiring President of the Conference would be eligible to fill one of the delegate vacancies occurring on the Committee.

#### FUTURE MEETINGS.

XVI.—It has been found desirable to determine the date of the Cambridge Meeting (1938) as soon as possible, and, following correspondence with the Vice-Chancellor of the University, the period of Wednesday, August 17, to Wednesday, August 24, is recommended.

The Council have received and gratefully acknowledged an invitation from the Town Council of Swansea to meet at Swansea whenever the Association so desires.

The formal invitation of the Indian Science Congress Association (accepted in principle by the General Committee in 1935) for the British Association to send a party to hold a joint session in India in January 1938, when the Indian Science Congress Association would celebrate its Silver Jubilee, was duly received and accepted by the Council under authority of the General Committee.

#### MISCELLANEA.

XVII. *Statutes*.—The following discrepancy in the Statutes has been brought to the notice of the Council :—

Chap. XI, 3. The Delegates of Corresponding Societies . . . shall constitute a Conference, of which the President and other officers shall be appointed by the Council.

Chap. II, 4. The General Committee shall . . . (x) Elect the officers of the Conference of Delegates.

Having regard to the fact that the Statute first quoted above is that under which the appointments in question are made, it is recommended that the line '(x) Elect the officers of the Conference of Delegates' be deleted from the Statutes.

XVIII. *Quinquennial Reports*.—It was stated in last year's *Report* (p. xxv) that the Council had considered suggestions for the publication by the Association of (a) a quinquennial report on the advancement of science, and (b) a short statement for general distribution, summarising the various activities of the Association. Effect has been given to these proposals.

Messrs. Sir Isaac Pitman & Sons will publish in the autumn, on behalf of the Association, and without cost to it, the first quinquennial review of the progress of science (1931-35), by a number of authors, to whom the Council take this opportunity of expressing their gratitude.

The short statement on the activities of the Association, referred to above, was drafted in the office and has been issued under the title *Five Years' Retrospect*. The Council here record their gratitude to sectional Recorders for kindly reading this statement in draft.

XIX. *Overseas Representatives*.—The Council resolved that a letter should be issued, with the preliminary programme of the Annual Meeting, to Dominion and Colonial universities and research institutions, indicating that members of their scientific staffs on leave in England would be welcome as guests at Annual Meetings.

XX. *Earth Pressures Committee*.—A letter has been received from the Institution of Civil Engineers, proposing that the work of the Earth Pressures Committee should be taken over by the Institution, and stating that the Council of the Institution had authorised the contribution of £200 per annum for the next two years in order that this research might be continued at the Building Research Station, with the existing committee as a sub-committee of the Institution's research committee. A letter from Mr. F. Wentworth-Sheilds, Secretary of the Committee, was also received. The Council resolved to accept the proposal, and expressed their satisfaction to the Institution and to Mr. Wentworth-Sheilds.

XXI. *A Sequel to the Norwich Meeting*.—Prof. W. W. Watts, F.R.S. (President, 1935), informed the Council that in response to his personal appeal for contributions from visiting members at the Norwich Meeting toward the restoration of the cathedral cloisters there, a sum of £140 10s. had been received.

XXII. *Armorial Bearings*.—A suggestion has been made that the Association should possess armorial bearings, and the Council are making sympathetic inquiry into the possibility of giving effect thereto.

#### DOWN HOUSE.

XXIII. The following report for the year 1935-36 has been received from the Down House Committee:—

The number of visitors to Down House during the year ending June 6, 1936, has been 7,022, compared with 6,658 in 1934-35.



Thanks to the kind offices of the Director of the Victoria and Albert Museum and the generosity of the Board of Education, two hats which formerly were Darwin's have been handed over to the Association from the Museum and are now exhibited at Down House. Original letters of Darwin's, presented by Prof. Van Dyck and Prof. G. D. Hale Carpenter, have been added to the collection. A sculptor's model of a seated figure of Darwin, the history of which is not at present known to the Committee, has been presented by Mr. J. Peacock.

Members of the Urban District Council of Orpington (in which district Down House is situated) were received at the house by Prof. W. W. Watts, F.R.S. (President), Sir Buckston Browne (Hon. Curator) and other members of the Committee on July 28, 1935. They were afterwards entertained at tea at the Buckston Browne Research Farm by invitation of Sir Arthur Keith, F.R.S.

The Committee are interested to learn that the Secretary, Dr. Howarth, is now chairman of the Town Planning Committee of the Urban District Council.

A new series of photographs of the house and grounds has been made and placed on sale: copies of some of them have been presented to appropriate learned societies for exhibition.

Considerable damage was done to buildings, trees and fences by the gale of September 23, 1935.

The Committee have obtained from a qualified architect a structural survey of the property with a view to informing themselves as to repairs and renewals which are or will become necessary in the next few years. They have given careful consideration to this and to kindred questions.

They have also constantly in mind the possibility of establishing on the property scientific records dependent upon instruments which it would be within the competence of the staff to read—and, indeed, of making any appropriate use of the property for purposes of research.

They therefore desire to support the proposal, which they understand the General Treasurer will bring before the Council, that a sum of money from the Spencer bequest or other funds of the Association should be earmarked to meet temporarily the cost of repairs and other works on the property, and the provision of facilities for scientific work as occasion may arise.

The following financial statement shows income and expenditure on account of Down House for the years ending March 31, 1935 and 1936:—

|  | <i>Income</i> |    |    | <i>Corresponding<br/>figures, 1934-35</i> |    |    |
|--|---------------|----|----|---|----|----|
|  | £             | s. | d. | £   | s. | d. |
| By Rents receivable . . . . .  | 141           | 0  | 0  | 141                                       | 0  | 0  |
| „ Income Tax recovered . . . . .   | 168           | 1  | 6  | 186                                       | 15 | 0  |
| „ Interest and Dividends . . . . .   | 826           | 8  | 6  | 826                                       | 8  | 6  |
| „ Donations . . . . .  | 16            | 7  | 2  | 4   | 14 | 0  |
| „ Sale of Postcards and Catalogues . . . . .   | 25            | 12 | 7  | 24  | 15 | 2  |
| „ Pilgrim Trust Grant . . . . .  | 150           | 0  | 0  | 150                                       | 0  | 0  |
| „ Balance, being excess of expenditure<br>over income, 1934-35, transferred to<br>Suspense Account . . . . . | —             |    |    | 84  | 13 | 1½ |
|  | £1,327        | 9  | 9  | £1,418                                    | 5  | 9½ |

*Expenditure*

|  | £      | s. | d. | £      | s. | d. |
|--|--------|----|----|--------|----|----|
| To Wages of Staff . . . . .  | 783    | 15 | 10 | 797    | 13 | 2  |
| „ Rates, Insurance, etc. . . . .   | 66     | 5  | 8  | 62     | 3  | 8½ |
| „ Coal, Coke, etc. . . . .   | 86     | 18 | 6  | 126    | 14 | 6  |
| „ Lighting and Drainage (including oil<br>and petrol) . . . . .  | 76     | 3  | 10 | 81     | 6  | 7  |
| „ Water . . . . .  | 15     | 16 | 8  | 14     | 16 | 7  |
| „ Surveyor's Fee . . . . .   | 5      | 5  | 0  | —      | —  | —  |
| „ Repairs and Renewals . . . . .   | 74     | 13 | 9  | 185    | 19 | 6  |
| „ Garden and Land: Materials and<br>Maintenance . . . . .  | 72     | 12 | 1  | 65     | 4  | 11 |
| „ Donations to Village Institutions . . . . .  | 5      | 5  | 0  | 5      | 5  | 0  |
| „ Household Requisites, etc. . . . .   | 15     | 19 | 4  | 30     | 12 | 7½ |
| „ Transport and Carriage . . . . .   | 2      | 13 | 11 | 3      | 18 | 10 |
| „ Accountants' Fees . . . . .  | 18     | 18 | 1  | 19     | 16 | 9  |
| „ Printing, Postage, Telephone and<br>Stationery . . . . .   | 39     | 0  | 0  | 24     | 13 | 7½ |
| „ Balance, being excess of income over<br>expenditure, 1935-36, transferred<br>to Suspense Account . . . . . | 64     | 2  | 1  | —      | —  | —  |
|  | £1,327 | 9  | 9  | £1,418 | 5  | 9½ |

GENERAL TREASURER'S ACCOUNT,  
1935-36



## Balance Sheet,

| Corresponding<br>Figures<br>31st March,<br>1935.<br>£ s. d. | LIABILITIES   |       |    |        |    |              |
|---|---|-------|----|--------|----|--------------|
|   |   |       |    | £      | s. | d.           |
|   | <b>GENERAL PURPOSES :—</b>  |       |    |        |    |              |
|   | Sundry Creditors . . . . .  |       |    | 195    | 5  | 11           |
|   | Hon. Sir Charles Parsons' gift<br>(£10,000) and legacy (£2,000) . . . . .                         |       |    | 12,000 | 0  | 0            |
|   | The late Sir Alfred Ewing's legacy . . . . .  |       |    | 500    | 0  | 0            |
|   | <i>Narrow Fund</i>  |       |    |        |    |              |
|   | As per last Account £5,473 14 8   |       |    |        |    |              |
|   | Less Transferred to In-<br>come and Expendi-<br>ture Account under<br>terms of the gift . . . . . | 358   | 8  | 4      |    |              |
|   |   |       |    | 5,115  | 6  | 4            |
|   | <i>Life Compositions</i>  |       |    |        |    |              |
|   | As per last Account . . . . .   | 2,748 | 12 | 2      |    |              |
|   | Add Received during<br>year . . . . .   | 168   | 0  | 0      |    |              |
|   |   | 2,916 | 12 | 2      |    |              |
|   | Less Transferred to In-<br>come and Expendi-<br>ture Account . . . . .                            | 25    | 10 | 0      |    |              |
|   |   |       |    | 2,891  | 2  | 2            |
|   | <i>Contingency Fund</i>   |       |    |        |    |              |
|   | As per last Account . . . . .   | 1,224 | 6  | 2½     |    |              |
|   | Add Amount trans-<br>ferred from Income<br>and Expenditure<br>Account . . . . .                   | 273   | 1  | 3½     |    |              |
|   |   |       |    | 1,497  | 7  | 6            |
|   | <i>Accumulated Fund</i> . . . . .   |       |    | 16,488 | 9  | 0            |
| 33,052 10 2½  |   |       |    |        |    | 38,687 10 11 |
|   | <b>SPECIAL PURPOSES :—</b>  |       |    |        |    |              |
|   | <i>Caird Fund</i>   |       |    |        |    |              |
|   | Balance at 1st April, 1935 . . . . .  |       |    | 9,806  | 3  | 10           |
|   | Less Excess of Expenditure over In-<br>come for the year . . . . .                                |       |    | 15     | 16 | 11           |
| 9,806 3 10  |   |       |    |        |    | 9,790 6 11   |
|   | <i>Mathematical Tables Fund</i>   |       |    |        |    |              |
|   | Sundry Donations . . . . .  |       |    | 2      | 11 | 0            |
|   | Receipts from Sales transferred<br>from Income and Expenditure<br>Account. . . . .                |       |    | 66     | 3  | 7            |
|   |   |       |    |        |    | 68 14 7      |
|   | <i>Cunningham Bequest</i>   |       |    |        |    |              |
|   | Balance at 1st April, 1935 . . . . .  |       |    | 1,549  | 3  | 4            |
|   | Less Excess of Expenditure over In-<br>come for the year . . . . .                                |       |    | 194    | 17 | 6            |
| 1,549 3 4   |   |       |    |        |    | 1,354 5 10   |
|   | Carried forward . . . . .   |       |    |        |    | 49,900 18 3  |

31st March, 1936

| Corresponding<br>Figures<br>31st March,<br>1935.<br>£ s. d. | ASSETS   |  |  | £ s. d.    | £ s. d.      |
|---|--|--|--|------------|--------------|
|   | GENERAL PURPOSES :—  |  |  |            |              |
|   | Investments as scheduled with Income<br>and Expenditure Account, No. 1 . |  |  | 38,204 3 7 |              |
|   | Sundry debtors and payments in ad-<br>vance . . . . .                    |  |  | 90 1 10    |              |
|   | Cash at bank . . . . .   |  |  | 349 9 7    |              |
|   | Cash in hand . . . . .   |  |  | 43 15 11   |              |
| 38,052 10 2½  |  |  |  | <hr/>      | 38,687 10 11 |
|   |  |  |  |            |              |
|   | SPECIAL PURPOSES :—  |  |  |            |              |
|   | <i>Caird Fund</i>  |  |  |            |              |
|   | Investments (see Income and Ex-<br>penditure Account, No. 2) . . .       |  |  | 9,582 16 3 |              |
|   | Cash at bank . . . . .   |  |  | 207 10 8   |              |
| 9,806 3 10  |  |  |  | <hr/>      | 9,790 6 11   |
|   |  |  |  |            |              |
|   | <i>Mathematical Tables Fund</i>  |  |  |            |              |
| —   | Cash at bank . . . . .   |  |  |            | 68 14 7      |
|   |  |  |  |            |              |
|   | <i>Cunningham Bequest</i>  |  |  |            |              |
|   | Investments (see Income and Ex-<br>penditure Account, No. 3) . . .       |  |  | 1,305 7 2  |              |
|   | Cash at bank . . . . .   |  |  | 48 18 8    |              |
| 1,549 3 4   |  |  |  | <hr/>      | 1,354 5 10   |
|   |  |  |  |            |              |
|   | Carried forward . . . . .  |  |  |            | 49,900 18 3  |

## Balance Sheet,

|   |  |   |    |    |         |    |    |         |    |            |
|---|--|---|----|----|---------|----|----|---------|----|------------|
| Corresponding<br>Figures<br>31st March,<br>1935.<br>£ s. d.   | LIABILITIES ( <i>continued</i> )               |   |    |    |         |    |    |         |    |            |
|   | Brought forward                                | £ | s. | d. | £       | s. | d. | £       | s. | d.         |
|   |  |   |    |    |         |    |    | 49,900  | 18 | 3          |
|   | <i>Toronto University Presentation Fund</i>    |   |    |    |         |    |    |         |    |            |
|   | Capital  | . | .  | .  | .       | .  | .  | 178     | 11 | 4          |
| 182 18 10   | Revenue  | . | .  | .  | .       | .  | .  | 4       | 7  | 6          |
|   |  |   |    |    |         |    |    |         |    | 182 18 10  |
|   | <i>Bernard Hobson Fund</i>                     |   |    |    |         |    |    |         |    |            |
|   | Capital  | . | .  | .  | .       | .  | .  | 1,000   | 0  | 0          |
|   | Revenue—Balance per                            |   |    |    |         |    |    |         |    |            |
|   | last Account                                   | . | .  | .  | 44      | 16 | 0  |         |    |            |
|   | Less Excess of Expen-                          |   |    |    |         |    |    |         |    |            |
|   | diture over Income                             |   |    |    |         |    |    |         |    |            |
|   | for the year                                   | . | .  | .  | 14      | 13 | 10 |         |    |            |
| 1,044 16 0  |  |   |    |    |         |    |    | 30      | 2  | 2          |
|   |  |   |    |    |         |    |    |         |    | 1,030 2 2  |
|   | <i>Leicester and Leicestershire Fund, 1933</i> |   |    |    |         |    |    |         |    |            |
|   | Capital  | . | .  | .  | .       | .  | .  | 1,000   | 0  | 0          |
|   | Revenue—Balance per                            |   |    |    |         |    |    |         |    |            |
|   | last Account                                   | . | .  | .  | 34      | 4  | 2  |         |    |            |
|   | Excess of Income over Ex-                      |   |    |    |         |    |    |         |    |            |
|   | penditure for the year                         | . | .  | .  | 31      | 4  | 2  |         |    |            |
| 1,034 4 2   |  |   |    |    |         |    |    | 65      | 8  | 4          |
|   |  |   |    |    |         |    |    |         |    | 1,065 8 4  |
|   | <i>Down House</i>                              |   |    |    |         |    |    |         |    |            |
|   | Endowment Fund                                 | . | .  | .  | .       | .  | .  | 20,000  | 0  | 0          |
|   | Sundry Creditors and Credit                    |   |    |    |         |    |    |         |    |            |
|   | Balances                                       | . | .  | .  | .       | .  | .  | 43      | 10 | 11         |
|   | <i>Suspense Account</i>                        |   |    |    |         |    |    |         |    |            |
|   | Excess of Income over                          |   |    |    |         |    |    |         |    |            |
|   | Expenditure for the                            |   |    |    |         |    |    |         |    |            |
|   | year   | . | .  | .  | 64      | 2  | 1  |         |    |            |
|   | Less balance at Debit                          |   |    |    |         |    |    |         |    |            |
|   | thereof, at 1/4/35                             | . | .  | .  | 39      | 3  | 5  |         |    |            |
| 20,150 12 8   |  |   |    |    |         |    |    | 24      | 18 | 8          |
|   |  |   |    |    |         |    |    |         |    | 20,068 9 7 |
|   | (Total of Special Funds                        |   |    |    | £33,560 | 6  | 3) |         |    |            |
| NOTE.—There are contingent Liabilities in respect of grants voted to Research Committees at Norwich in 1935 but not claimed at 31st March, 1936, amounting to £429 14s. 3d.   |  |   |    |    |         |    |    |         |    |            |
| The amount which should, in accordance with Council's resolution, have been in the Contingency Fund at 31st March, 1936, was £1,875, but the surplus income available for this purpose has been insufficient by £377 12s. 6d. to meet the full annual amounts transferable. |  |   |    |    |         |    |    |         |    |            |
| 71,820 9 0½   |  |   |    |    |         |    |    | £72,247 | 17 | 2          |

I have examined the foregoing Account with the Books and Vouchers and certify and the Investments, and the Bank have certified to me that they hold the

Approved, A. L. BOWLEY  
EZER GRIFFITHS } Auditors.



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[illegible]

23 Queen Victoria St., London, E.C. 4.  
28th May, 1936.

### INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH, 1936.

## No. 1. General Income and Expenditure

| Investments :   |         |      | Consolidated 2½ per cent. Stock, at cost .                 |  |       | £       | s.  | d.         |
|---|---------|------|--|--|-------|---------|-----|------------|
| 2d.   | £6,749  | 12s. | India 3 per cent. Stock, at cost                           | .  | .     | 5,142   | 3   | 3          |
| 0d.   | £3,600  | 0s.  | Great Indian Peninsula Railway 'B' Annuity £43, at cost    | .  | .     | 3,522   | 2   | 6          |
| 9d.   | £879    | 14s. | War Stock (Post Office Issue), at cost                     | .  | .     | 827     | 15  | 0          |
| 7d.   | £52     | 12s. | 3½ per cent. War Loan Bonds, at cost                       | .  | .     | 54      | 5   | 2          |
| 0d.   | £1,400  | 0s.  | 3½ per cent. War Loan Inscribed Stock, at cost             | .  | .     | 1,393   | 16  | 11         |
| 1d.   | £7,944  | 16s. | 4½ per cent. Conversion Stock, at cost                     | .  | .     | 7,987   | 12  | 4          |
| 6d.   | £11,134 | 16s. | 3½ per cent. Conversion Stock, at cost                     | .  | .     | 10,835  | 12  | 4          |
| 7d.   | £6,368  | 15s. | 4½ per cent. Conversion Stock (Post Office Issue), at cost | .  | .     | 5,304   | 8   | 11         |
| 0d.   | £94     | 7s.  | 3 per cent. Local Loans, at cost                           | .  | .     | 62      | 15  | 0          |
| 2d.   | £4,184  | 18s. |  |  |       | 3,073   | 12  | 2          |
| (Value of Stocks at 29/3/35, £42,886 os. 11d.)          |         |      |  |  |       | £38,204 | 3   | 7          |
|   |         |      |  |  |       | £43,633 | 2s. | 1d.)       |
|   |         |      |  |  |       |         |     |            |
| EXPENDITURE   |         |      | INCOME   |  |       |         |     |            |
| To Heat, Lighting and Power                             | £       | s.   | d.   | By Old Annual Regular Members  | £     | s.      | d.  |            |
| Stationery . . . . .                                    | 70      | 8    | 10½  | " Annual members for Meeting only . . . . .                                | 86    | 19      | 11  |            |
| Rent . . . . .  | 1       | 0    | 0  | " Annual members, with Report . . . . .                                    | 1,514 | 0       | 0   |            |
| Postages . . . . .                                      | 173     | 6    | 0  | " Transferable Tickets . . . . .   | 426   | 0       | 0   |            |
| Travelling expenses . . . . .                           | 251     | 2    | 8½   | " Student members . . . . .  | 173   | 18      | 0   |            |
| Exhibitioners . . . . .                                 | 133     | 0    | 4  | " Life compositions : amount transferred on expiry of membership . . . . . | 95    | 17      | 6   | 2,296 15 5 |
| Audit and Accountancy . . . . .                         | 38      | 12   | 3  | " Sale of Publications . . . . .   |       |         |     | 25 10 0    |
| Royal Jubilee Decorations (share of expenses) . . . . . | —       | —    | —  | " Advertisements in B.A. publications . . . . .                            |       |         |     | 455 10 6   |
| Cost of optiscopes . . . . .                            | —       | —    | —  | " Unexpended balances of grants, returned . . . . .                        |       |         |     | 303 16 9   |
| Hire of epidiascopes . . . . .                          | 350     | 4    | 8½   | " Liverpool Exhibitioners . . . . .  |       |         |     | 8 0 5      |
| Sundries . . . . .                                      | 1,993   | 4    | 9  |  |       |         |     | 13 10 0    |
| Salaries and wages . . . . .                            | 75      | 0    | 0  |  |       |         |     |            |
| Pension contributions . . . . .                         | 1,276   | 8    | 5  |  |       |         |     |            |
| Printing, binding, etc. . . . .                         | 4,394   | 13   | 5½   |  |       |         |     |            |

# GENERAL TREASURER'S ACCOUNT

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|  |        |    |     |                           |       |    |    |
|--|--------|----|-----|---------------------------|-------|----|----|
| To Grants made to Research Committees by General Committee 1934, 1935:           | 63     | 17 | 2   | By Income Tax recovered   | 16    | 16 | 7  |
| Inland Water Survey  | 10     | 0  | 0   | Interest on investments   | 1,466 | 11 | 1  |
| North East Land  | 25     | 0  | 0   | Donations                 | 3     | 12 | 6  |
| Sumerian Copper  | 15     | 0  | 0   | Sir Alfred Yarrow's Gift: |       |    |    |
| Freshwater Biological Station  | 75     | 0  | 0   | amount transferred        | 358   | 8  | 4  |
| Plymouth Laboratory  | 50     | 0  | 0   |                           |       |    |    |
| Human Geography of Inter-Tropical Africa   | 1      | 5  | 0   |                           |       |    |    |
| Brancaster Fort  | 25     | 0  | 0   |                           |       |    |    |
| Derbyshire Caves   | 25     | 0  | 0   |                           |       |    |    |
| Palestine Caves  | 40     | 0  | 0   |                           |       |    |    |
| Chronology of the World Crisis   | 3      | 0  | 0   |                           |       |    |    |
| Mathematical Tables  | 68     | 11 | 0   |                           |       |    |    |
| Reduction of Noise   | 5      | 0  | 0   |                           |       |    |    |
|  |        |    | 342 |                           |       |    |    |
| 167 9 4  |        |    |     |                           |       |    |    |
| 100 0 0  |        |    |     |                           |       |    |    |
| 13 0 0   |        |    |     |                           |       |    |    |
| " Grant to Parsons Memorial Fund   |        |    |     |                           |       |    |    |
| " Expenses of Noise Committee's Demonstrations                                   |        |    |     |                           |       |    |    |
| " Publications—  |        |    |     |                           |       |    |    |
| Receipts from sales transferred to Mathematical Tables Fund                      | 66     | 3  | 7   |                           |       |    |    |
| Sir J. B. Harrison's Monograph: Receipts from sales transferred to Caird Fund    | 24     | 16 | 5   |                           |       |    |    |
|  |        |    | 91  |                           |       |    |    |
| " Balance, being excess of income over expenditure for the year carried down     | 273    | 1  | 3½  |                           |       |    |    |
|  |        |    |     |                           |       |    |    |
| 454 8 3½   |        |    |     |                           |       |    |    |
| 5,429 11 1   |        |    |     |                           |       |    |    |
| To amount transferred to Contingency Fund  | £4,948 | 11 | 7   |                           |       |    |    |
| Grants to research authorised but not yet claimed at 31st March, 1936, amount to | £273   | 1  | 3½  | By balance brought down   | £273  | 1  | 3½ |
|  |        |    |     |                           |       |    |    |
| 454 8 3½   |        |    |     |                           |       |    |    |
|  |        |    |     |                           |       |    |    |



## GENERAL TREASURER'S ACCOUNT

No. 2. Caird-Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by the General Committee in 1913.

[illegible]

## No. 3. Cunningham Bequest

A legacy received by the Association in 1929 in trust under the will of Lt.-Col. A. J. C. Cunningham, for the preparation of new mathematical tables in the theory of numbers ; administered by the Council.

### Investments :

|                 |  |   |   |   |     |    |    |
|-----------------|--|---|---|---|-----|----|----|
| £1,187 6s. 10d. | Consolidated 2½ per cent. Stock            | • | • | • | £   | s. | d. |
| £300 0s. 0d.    | Port of London 3½ per cent. Stock, 1949/99 | • | • | • | 653 | 0  | 9  |
| £862 13s. 3d.   | Local Loans 3 per cent. Stock, at cost     | • | • | • | 216 | 0  | 0  |
|                 |  |   |   |   | 436 | 6  | 5  |

(Value at 29/3/35, £2,352 3s. od.)

£1,305 7 2  
Cash at bank, £48 18s. 8d.

### EXPENDITURE

|   | £    | s. | d. | Corresponding<br>Figures<br>31st March,<br>1935. |
|---|------|----|----|--|
| To Grants for the preparation of tables | 34   | 14 | 0  | £ 94 1 3   |
| „ Printing and Binding                  | 257  | 11 | 6  | 8 12 6   |
|   |      |    |    | —  |
|   | 735  | 15 | 9  |  |
|   | £292 | 5  | 6  | 838 9 6  |

|  |      |   |   |     |    |    |
|--|------|---|---|-----|----|----|
| By Interest                                      | •    | • | • | £   | s. | d. |
| „ Income Tax recovered                           | •    | • | • | 73  | 9  | 2  |
| „ Profits on realisation of securities           | •    | • | • | 2   | 9  | 10 |
| „ Excess of Expenditure over Income for the year | •    | • | • | 21  | 9  | 0  |
|  | •    | • | • | 194 | 17 | 6  |
|  | £292 | 5 | 6 |     |    |    |

### INCOME

## No. 4. Toronto University Presentation Fund

A fund voluntarily subscribed by members present at the Toronto Meeting in 1924. From the income a presentation of two bronze medals each year is made, together with presents of books, to selected students in pure and applied science respectively.

Investment : £175 3½ per cent. War Stock at cost

(Value at 29/3/35, £189 15s. od.)

|  |   |    |    |
|--|---|----|----|
| Corresponding<br>Figures<br>31st March,<br>1935. | £ | s. | d. |
| 178 11 4   |   |    |    |

Cash at bank, £4 7s. 6d.

### EXPENDITURE

|           | £  | s. | d. | Corresponding<br>Figures<br>31st March,<br>1935. |
|-----------|----|----|----|--|
| To awards | £6 | 2  | 6  | £ 6 2 6  |

|             |   |   |   |    |    |    |
|-------------|---|---|---|----|----|----|
| By Interest | • | • | • | £  | s. | d. |
|             | • | • | • | £6 | 2  | 6  |

### INCOME

# No. 5. Bernard Hobson Fund

The bequest of Mr. Bernard Hobson, 1933; the income to be applied to the promotion of geological research; administered by the Council.

Investments:

| Corresponding<br>Figures<br>31st March,<br>1935.<br>£ s. d. | £450 0s. 0d. | 4 per cent. Victory (Bearer) Bonds at cost | £ s. d.                               |
|---|--------------|--|---------------------------------------|
|   | £601 9s. 0d. | 3 per cent. Local Loans at cost            | 491 13 6                              |
|   |              |  | 508 6 6                               |
|   |              |  | <u>£1,000 0 0</u>                     |
|   |              |  | (Value at 31/3/36,<br>£1,095 5s. 5d.) |

Cash at bank, £30 2s. 2d.

## EXPENDITURE

| To Grants Paid  | £ s. d.         |
|---|-----------------|
| " Excess of income over expenditure for the year                          | 55 17 7         |
|   | —               |
|   | <u>£55 17 7</u> |
| Grants to research authorised, not claimed at 31st March, 1936, amount to | £44 2 5         |

Corresponding  
Figures  
31st March,  
1935.  
£ s. d.

## INCOME

|  |                 |
|--|-----------------|
| By Interest                                      | £ s. d.         |
| " Unexpended balance of grant returned           | 32 0 0          |
| " Income Tax Recovered                           | 5 2 9           |
| " Excess of Expenditure over Income for the year | 4 1 0           |
|  | 14 13 10        |
|  | <u>£55 17 7</u> |



## No. 6. Leicester and Leicestershire Fund, 1933

Corresponding  
Figures  
31st March,  
1935.

£ s. d.

The unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science; administered by the Council.

*Investments:*

|      |          |                                       |   |   |   |     |
|------|----------|---------------------------------------|---|---|---|-----|
| £487 | 2s. 11d. | 3½ per cent. Conversion Stock at cost | . | . | . | £   |
| £490 | 5s. 11d. | 3½ per cent. War Stock at cost        | . | . | . | 500 |
|      |          |                                       |   |   |   | 500 |

(Value at 31/3/36,  
£1,025 16s. 4d.)

(Value at 29/3/35, £1,025 16s. 4d.)

1,000 0 0

Cash at bank, £65 8s. 4d.

## EXPENDITURE

|  |   |   |   |    |    |    |
|--|---|---|---|----|----|----|
| To Grant paid                                    | . | . | . | £  | s. | d. |
| " Excess of Income over Expenditure for the year | . | . | . | 3  | 0  | 0  |
|  | . | . | . | 31 | 4  | 2  |
|  | . | . | . | 34 | 4  | 2  |

Grants to research authorised but not yet claimed at 31st March, 1936, amount to . . . . £47 0 0

## INCOME

|             |   |   |   |    |    |    |
|-------------|---|---|---|----|----|----|
| By Interest | . | . | . | £  | s. | d. |
|             | . | . | . | 34 | 4  | 2  |
|             | . | . | . | 34 | 4  | 2  |



|            |  |   |   |            |
|------------|--|---|---|------------|
| 185 19 6   | To Repairs and Renewals  | . | . | 74 13 9    |
| 65 4 11    | " Garden and Land :  |   |   |            |
| 5 5 0      | Materials and Maintenance  | . | . | 72 12 1    |
| 30 12 7½   | Donations to Village Institutions  | . | . | 5 5 0      |
| 3 18 10    | Household Requisites, etc.   | . | . | 15 19 4    |
| 19 16 9    | Transport and Carriage   | . | . | 2 13 11    |
|            | Accountants' Fees  | . | . | 18 18 1    |
|            | Printing, Postages, Telephone, and Stationery  | . | . | 39 0 0     |
| 24 13 7½   | Balance, being excess of income over expenditure for 1935/36 transferred to Suspense Account | . | . | 64 2 1     |
| —          |  |   |   | 84 13 1½   |
| 1,418 5 9½ |  |   |   | 1,418 5 9½ |
|            |  |   |   | £1,327 9 9 |
|            |  |   |   | £1,327 9 9 |

*By Balance, being excess of expenditure over income for 1934/35, transferred to Suspense Account*



# RESEARCH COMMITTEES, Etc.

APPOINTED BY THE GENERAL COMMITTEE, MEETING IN  
BLACKPOOL, 1936.

*Grants of money, if any, from the Association for expenses connected with researches are indicated in heavy type.*

## SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCES.

Seismological investigations.—Dr. F. J. W. Whipple (*Chairman*), Mr. J. J. Shaw, C.B.E. (*Secretary*), Miss E. F. Bellamy, Prof. P. G. H. Boswell, O.B.E., F.R.S., Dr. A. T. J. Dollar, Sir Frank Dyson, K.B.E., F.R.S., Prof. G. R. Goldsbrough, F.R.S., Dr. Wilfred Hall, Mr. J. S. Hughes, Dr. H. Jeffreys, F.R.S., Mr. Cosmo Johns, Dr. A. W. Lee, Prof. E. A. Milne, M.B.E., F.R.S., Prof. H. H. Plaskett, F.R.S., Prof. H. C. Plummer, F.R.S., Prof. A. O. Rankine, O.B.E., Rev. C. Rey, S.J., Rev. J. P. Rowland, S.J., Prof. R. A. Sampson, F.R.S., Mr. F. J. Scrase, Capt. H. Shaw, Sir Frank Smith, K.C.B., C.B.E., Sec. R.S., Dr. R. Stoneley, F.R.S., Mr. E. Tillotson, Sir G. T. Walker, C.S.I., F.R.S. **£150** (Caird Fund grant).

Calculation of mathematical tables.—Prof. E. H. Neville (*Chairman*), Dr. L. J. Comrie (*Secretary*), Prof. A. Lodge (*Vice-Chairman*), Dr. J. R. Airey, Dr. W. G. Bickley, Prof. R. A. Fisher, F.R.S., Dr. J. Henderson, Dr. E. L. Ince, Dr. J. O. Irwin, Dr. J. C. P. Miller, Mr. F. Robbins, Mr. D. H. Sadler, Dr. A. J. Thompson, Dr. J. F. Tocher, Dr. J. Wishart. **£150** (Caird Fund grant).

## SECTIONS A, B, I.—MATHEMATICAL AND PHYSICAL SCIENCES, CHEMISTRY, PHYSIOLOGY.

To co-ordinate the activities of Sections A, B, I, as regards joint symposia, etc., in so far as these relate to the Sciences lying on the border-lines between Physics, Chemistry, and Physiology.—Prof. David Burns, Prof. J. M. Gulland, Dr. P. B. Moon, Prof. H. S. Raper, C.B.E., F.R.S., Prof. S. Sugden, F.R.S., Dr. D. M. Wrinch.

## SECTIONS A, C.—MATHEMATICAL AND PHYSICAL SCIENCES, GEOLOGY.

The direct determination of the thermal conductivities of rocks in mines or borings where the temperature gradient has been, or is likely to be, measured.—Dr. Ezer Griffiths, F.R.S. (*Chairman*), Dr. D. W. Phillip (*Secretary*), Dr. E. C. Bullard, Dr. H. Jeffreys, F.R.S. (*from Section A*); Dr. E. M. Anderson, Prof. W. G. Fearnside, F.R.S., Prof. G. Hickling, F.R.S., Prof. A. Holmes, Dr. J. H. J. Poole. **£25** (Part from Bernard Hobson Fund).

## SECTIONS A, J.—MATHEMATICAL AND PHYSICAL SCIENCES, PSYCHOLOGY.

The possibility of quantitative estimates of sensory events.—Prof. A. Ferguson (*Chairman*), Dr. C. S. Myers, C.B.E., F.R.S. (*Vice-Chairman*), Mr. R. J. Bartlett (*Secretary*), Dr. H. Banister, Prof. F. C. Bartlett, F.R.S., Dr. Wm. Brown, Dr. N. R. Campbell, Prof. J. Drever, Mr. J. Guild, Dr. R. A. Houstoun, Dr. J. O. Irwin, Dr. G. W. C. Kaye, Dr. S. J. F. Philpott, Dr. L. F. Richardson, F.R.S., Dr. J. H. Shaxby, Mr. T. Smith, F.R.S., Dr. R. H. Thouless, Dr. W. S. Tucker, O.B.E.

## SECTION C.—GEOLOGY.

- To excavate critical geological sections in Great Britain.—Prof. W. T. Gordon (*Chairman*), Prof. W. G. Fearnside, F.R.S. (*Secretary*), Prof. E. B. Bailey, F.R.S., Mr. H. C. Berdinner, Mr. W. S. Bisat, Prof. P. G. H. Boswell, O.B.E., F.R.S., Prof. W. S. Boulton, Prof. A. H. Cox, Miss M. C. Crosfield, Mr. E. E. L. Dixon, Dr. Gertrude Elles, M.B.E., Prof. E. J. Garwood, F.R.S., Mr. F. Gossling, Prof. H. L. Hawkins, Prof. G. Hickling, F.R.S., Prof. V. C. Illing, Prof. O. T. Jones, F.R.S., Dr. Murray Macgregor, Dr. F. J. North, Dr. J. Pringle, Dr. T. F. Sibly, Dr. W. K. Spencer, F.R.S., Prof. A. E. Trueman, Dr. F. S. Wallis, Prof. W. W. Watts, F.R.S., Dr. W. F. Whittard, Dr. S. W. Wooldridge. £25 (Contingent grant).
- To investigate the reptile-bearing oolite of Stow-on-the-Wold, subject to the condition that suitable arrangements be made for the disposal of the material.—Sir A. Smith Woodward, F.R.S. (*Chairman*), Mr. C. I. Gardiner (*Secretary*), Prof. S. H. Reynolds, Mr. W. E. Swinton. £25 (Bernard Hobson Fund grant).
- To investigate the bone-bed in the glacial deposits of Brundon, near Sudbury, Suffolk.—Prof. W. B. R. King, O.B.E. (*Chairman*), Mr. Guy Maynard (*Secretary*), Mr. D. F. W. Baden-Powell, Prof. P. G. H. Boswell, O.B.E., Mr. J. P. T. Burchell, Mr. J. Reid Moir, Mr. K. P. Oakley, Mr. C. D. Ovey, Dr. J. D. Solomon, Sir A. Smith Woodward, F.R.S. £25 (Bernard Hobson Fund grant).
- To consider and report on questions affecting the teaching of Geology in schools.—Prof. W. W. Watts, F.R.S. (*Chairman*), Prof. A. E. Trueman (*Secretary*), Prof. P. G. H. Boswell, O.B.E., F.R.S., Mr. C. P. Chatwin, Prof. A. H. Cox, Miss E. Dix, Prof. W. G. Fearnside, F.R.S., Prof. A. Gilligan, Prof. G. Hickling, F.R.S., Prof. D. E. Innes, Prof. A. G. Ogilvie, O.B.E., Prof. H. H. Swinnerton, Dr. A. K. Wells.
- The collection, preservation, and systematic registration of photographs of geological interest.—Prof. E. J. Garwood, F.R.S. (*Chairman*), Prof. S. H. Reynolds (*Secretary*), Mr. H. Ashley, Mr. C. V. Crook, Mr. G. Macdonald Davies, Mr. J. F. Jackson, Dr. A. G. Macgregor, Dr. F. J. North, Dr. A. Raistrick, Mr. J. Ranson, Prof. W. W. Watts, F.R.S.
- To consider and report upon petrographic classification and nomenclature.—Mr. W. Campbell Smith (*Chairman and Secretary*), Prof. E. B. Bailey, F.R.S., Dr. R. Campbell, Dr. W. Q. Kennedy, Mr. A. G. MacGregor, Dr. S. I. Tomkeieff, Dr. G. W. Tyrrell, Dr. F. Walker, Dr. A. K. Wells. £3.

## SECTION D.—ZOOLOGY.

- To nominate competent naturalists to perform definite pieces of work at the Marine Laboratory, Plymouth.—Prof. J. Stanley Gardiner, F.R.S. (*Chairman and Secretary*), Prof. H. Graham Cannon, F.R.S., Prof. H. Munro Fox, Dr. J. S. Huxley, Prof. H. G. Jackson, Prof. C. M. Yonge. £50 (Caird Fund grant).
- To co-operate with other sections interested, and with the Zoological Society, for the purpose of obtaining support for the Zoological Record.—Sir Sidney Harmer, K.B.E., F.R.S. (*Chairman*), Dr. W. T. Calman, C.B., F.R.S. (*Secretary*), Prof. E. S. Goodrich, F.R.S., Prof. D. M. S. Watson, F.R.S. £50 (Caird Fund grant).
- To investigate British immigrant insects.—Sir E. B. Poulton, F.R.S. (*Chairman*), Dr. C. B. Williams (*Secretary*), Prof. F. Balfour-Browne, Capt. N. D. Riley. £10.
- To consider the position of animal biology in the school curriculum and matters relating thereto.—Prof. R. D. Laurie (*Chairman and Secretary*), Mr. P. Ainslie, Mr. Cousins, Dr. J. S. Huxley, Mr. Percy Lee, Mr. A. G. Lowndes, Prof. E. W. MacBride, F.R.S., Dr. W. K. Spencer, F.R.S., Prof. W. M. Tattersall, Dr. E. N. Miles Thomas.

The progressive adaptation to new conditions in *Artemia salina* (Diploid and Octoploid, Parthenogenetic *v.* Bisexual).—Prof. R. A. Fisher, F.R.S. (*Chairman*), Dr. K. Mather (*Secretary*), Dr. J. Gray, F.R.S., Dr. F. Gross, Dr. J. S. Huxley, Dr. E. S. Russell, O.B.E., Prof. D. M. S. Watson, F.R.S. **£15.**

To confer with the Museums Association on matters concerning the place and function of the Museum in Zoology.—Dr. J. S. Huxley (*Chairman*), Dr. A. C. Stephen (*Secretary*), Dr. W. T. Calman, C.B., F.R.S., Prof. W. M. Tattersall, Prof. C. M. Yonge.

#### SECTIONS D, I, K.—ZOOLOGY, PHYSIOLOGY, BOTANY.

To aid competent investigators selected by the Committee to carry on definite pieces of work at the Zoological Station at Naples.—Prof. E. W. MacBride, F.R.S. (*Chairman and Secretary*), Dr. Margery Knight, Prof. Sir Joseph Barcroft, C.B.E., F.R.S., Dr. J. Z. Young. **£50.**

#### SECTIONS D, K.—ZOOLOGY, BOTANY.

To aid competent investigators selected by the Committee to carry out definite pieces of work at the Freshwater Biological Station, Wray Castle, Windermere.—Prof. F. E. Fritsch, F.R.S. (*Chairman*), Prof. P. A. Buxton (*Secretary*), Miss P. M. Jenkin, Dr. C. H. O'Donoghue (*from Section D*); Dr. W. H. Pearsall (*from Section K*). **£75.**

Co-ordinating committee for Cytology and Genetics.—Prof. Dame Helen Gwynne-Vaughan, G.B.E. (*Chairman*), Dr. F. W. Sansome (*Secretary*), Prof. F. T. Brooks, F.R.S., Prof. F. A. E. Crew, Dr. C. D. Darlington, Prof. R. A. Fisher, F.R.S., Mr. E. B. Ford, Prof. R. R. Gates, F.R.S., Dr. C. Gordon, Dr. Hammond, Dr. J. S. Huxley, Dr. T. J. Jenkin, Dr. W. B. Turrill, Dr. C. H. Waddington.

#### SECTION E.—GEOGRAPHY.

To inquire into the present state of knowledge of the human geography of Tropical Africa, and to make recommendations for furtherance and development.—Prof. P. M. Roxby (*Chairman*), Prof. A. G. Ogilvie, O.B.E. (*Secretary*), Dr. A. Geddes (*Assistant Secretary*), Mr. S. J. K. Baker, Miss D. M. Doveton, Prof. C. B. Fawcett, Mr. W. Fitzgerald, Prof. H. J. Fleure, F.R.S., Mr. R. H. Kinvig, Mr. J. McFarlane, Brig. M. N. MacLeod, D.S.O., Prof. J. L. Myres, O.B.E., F.B.A., Mr. R. A. Pelham, Mr. R. U. Sayce, Rev. E. W. Smith, Brig. H. S. L. Winterbotham, C.B., C.M.G., D.S.O. **£3.**

To co-operate with bodies concerned with the cartographic representation of population, and in particular with the Ordnance Survey, for the production of population maps.—(*Chairman*), Prof. C. B. Fawcett (*Secretary*), The Director General of the Ordnance Survey, Col. Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S., Prof. H. J. Fleure, F.R.S., Mr. A. C. O'Dell, Mr. A. V. Williamson.

Insolation and population.—Prof. R. N. Rudmose Brown (*Secretary*), Prof. F. Debenham, Dr. L. Dudley Stamp. **£25.**

#### SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

Chronology of the world crisis from 1929 onwards.—Prof. J. H. Jones (*Chairman*), Dr. P. Ford (*Secretary*), Prof. G. C. Allen, Dr. C. R. Fay, Mr. H. M. Hallsworth, C.B.E., Mr. R. F. Harrod, Mr. A. Radford, Prof. J. G. Smith. **£10** (**£7** unexpended balance).

#### SECTION G.—ENGINEERING.

To review the knowledge at present available for the reduction of noise, and the nuisances to the abatement of which this knowledge could best be



applied.—Sir Henry Fowler, K.B.E. (*Chairman*), Wing-Commander T. R. Cave-Browne-Cave, C.B.E. (*Secretary*), Mr. R. S. Capon, Dr. A. H. Davis, Prof. G. W. O. Howe, Mr. E. S. Shrapnell-Smith, C.B.E. £10 (unexpended balances).

Electrical terms and definitions.—Prof. Sir J. B. Henderson (*Chairman*), Prof. F. G. Baily and Prof. G. W. O. Howe (*Secretaries*), Prof. W. Cramp, Prof. W. H. Eccles, F.R.S., Prof. C. L. Fortescue, Prof. A. E. Kennelly, Prof. E. W. Marchant, Prof. J. Proudman, F.R.S., Sir Frank Smith, K.C.B., C.B.E., Sec. R.S., Prof. L. R. Wilberforce.

## SECTION H.—ANTHROPOLOGY.

To co-operate with a committee of the Royal Anthropological Institute in assisting Miss G. Caton-Thompson to investigate the prehistoric archaeology of the Kharga Oasis.—Dr. H. S. Harrison (*Chairman*), Prof. J. L. Myres, O.B.E., F.B.A. (*Secretary*), Miss G. Caton-Thompson, Mr. H. J. E. Peake. £25.

To report on the probable sources of the supply of copper used by the Sumerians.—Mr. H. J. E. Peake (*Chairman*), Dr. C. H. Desch, F.R.S. (*Secretary*), Mr. H. Balfour, F.R.S., Mr. L. H. Dudley Buxton, Prof. V. Gordon Childe, Mr. O. Davies, Prof. H. J. Fleure, F.R.S., Dr. A. Raistrick, Dr. R. H. Rastall.

To co-operate with the Torquay Antiquarian Society in investigating Kent's Cavern.—Sir A. Keith, F.R.S. (*Chairman*), Prof. J. L. Myres, O.B.E., F.B.A. (*Secretary*), Mr. M. C. Burkitt, Miss D. A. E. Garrod, Mr. A. D. Lacaille. £5.

To excavate the Roman fort at Brancaster, Norfolk.—Mr. M. C. Burkitt (*Chairman*), Mr. V. E. Nash Williams (*Secretary*), Mr. K. H. Jackson. £20.

To investigate blood groups among primitive peoples.—Prof. H. J. Fleure (*Chairman*), Prof. R. Ruggles Gates, F.R.S. (*Secretary*), Dr. J. H. Hutton, C.I.E., Dr. F. W. Lamb, Mr. R. U. Sayce. £10.

To co-operate with a Committee of the Royal Anthropological Institute in the exploration of caves in the Derbyshire district.—Mr. M. C. Burkitt (*Chairman*), Mr. A. Leslie Armstrong (*Secretary*), Prof. H. J. Fleure, F.R.S., Miss D. A. E. Garrod, Dr. J. Wilfred Jackson, Prof. L. S. Palmer, Mr. H. J. E. Peake. £25.

To carry out research among the Ainu of Japan.—Prof. C. G. Seligman, F.R.S. (*Chairman*), Mrs. C. G. Seligman (*Secretary*), Dr. H. S. Harrison, Capt. T. A. Joyce, O.B.E., Rt. Hon. Lord Raglan.

To report on the classification and distribution of rude stone monuments in the British Isles.—Mr. H. J. E. Peake (*Chairman*), Dr. Margaret A. Murray (*Secretary*), Mr. A. L. Armstrong, Mr. H. Balfour, F.R.S., Mrs. E. M. Clifford, Sir Cyril Fox, Mr. T. D. Kendrick.

To conduct archaeological and ethnological researches in Crete.—Prof. J. L. Myres, O.B.E., F.B.A. (*Chairman*), Dr. G. M. Morant (*Secretary*), Mr. L. Dudley Buxton, Dr. W. L. H. Duckworth.

To report to the Sectional Committee on the question of re-editing 'Notes and Queries in Anthropology.'—Prof. H. J. Fleure, F.R.S. (*Chairman*), Mr. Elwyn Davies (*Secretary*), Dr. H. S. Harrison, Dr. G. M. Morant, Prof. C. G. Seligman, F.R.S., Mrs. C. G. Seligman.

To investigate early mining sites in Wales.—Mr. H. J. E. Peake (*Chairman*), Mr. Oliver Davies (*Secretary*), Prof. V. Gordon Childe, Dr. C. H. Desch, F.R.S., Mr. E. Estyn Evans, Prof. H. J. Fleure, F.R.S., Prof. C. Daryll Forde, Sir Cyril Fox, Dr. Willoughby Gardner, Dr. F. J. North, Mr. V. E. Nash Williams. £5.

## SECTION I.—PHYSIOLOGY.

To deal with the use of a stereotactic instrument.—Prof. J. Mellanby, F.R.S. (*Chairman and Secretary*).

## SECTION J.—PSYCHOLOGY.

To develop tests of the routine manual factor in mechanical ability.—Dr. C. S. Myers, C.B.E., F.R.S. (*Chairman*), Dr. G. H. Miles (*Secretary*), Prof. C. Burt, Dr. F. M. Earle, Dr. Ll. Wynn Jones, Prof. T. H. Pear. £30 (Leicester and Leicestershire Fund grant).

The nature of perseveration and its testing.—Prof. F. Aveling (*Chairman*), Dr. W. Stephenson (*Secretary*), Prof. F. C. Bartlett, F.R.S., Dr. Mary Collins, Mr. E. Farmer, Dr. P. E. Vernon. £10 (Leicester and Leicestershire Fund grant).

## SECTION K.—BOTANY.

Transplant experiments.—Sir Arthur Hill, K.C.M.G., F.R.S. (*Chairman*), Dr. W. B. Turrill (*Secretary*), Prof. F. W. Oliver, F.R.S., Prof. E. J. Salisbury, F.R.S., Prof. A. G. Tansley, F.R.S. £5.

## SECTION L.—EDUCATIONAL SCIENCE.

To consider and report upon the place of Science in Adult Education.—Dr. A. W. Pickard-Cambridge (*Chairman*), Mr. A. Gray Jones (*Secretary*), Mrs. V. Adams, Prof. W. B. Brierley, Prof. L. E. S. Eastham, Sir Richard Gregory, Bart., F.R.S., Mr. A. E. Henshall, Prof. R. Peers. £10.

## CORRESPONDING SOCIETIES.

Corresponding Societies Committee.—The President of the Association (*Chairman ex-officio*), Dr. C. Tierney (*Secretary*), the General Secretaries, the General Treasurer, Dr. Vaughan Cornish, Mr. T. S. Dymond, Sir A. E. Kitson, C.M.G., C.B.E., Dr. A. B. Rendle, F.R.S., Mr. T. Sheppard, Dr. G. F. Herbert Smith.

## RESOLUTIONS & RECOMMENDATIONS.

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The following resolutions and recommendations were referred to the Council by the General Committee at the Blackpool Meeting for consideration and, if desirable, for action :

### *From Section B (Chemistry).*

The members of Committee of Section B, in agreement with the views expressed in their President's address regarding science and warfare, request the General Committee to secure all possible publicity for the following : (1) The extent to which Chemistry is applied for beneficent purposes in connection with the industry of the British nation and the health of its citizens, is enormously greater than the scope of its employment for purposes of warfare. (2) Whilst the individual must remain free to determine his own action in relation to national defence, chemists as a body view with grave concern the increasing use of science for destructive ends.

### *From Section C (Geology).*

The Committee of Section C desire to call the attention of Council to the Report which has been drawn up for them on the Teaching of Geology in Schools. Enquiries have shown that the subject is practically excluded from all but a few schools. This is already producing a dearth of able students at the universities, with a consequent narrowing of the basis of recruitment for professional geologists, and it is likely to produce a decline in the standard of research in this country.

### *From Section C (Geology).*

The Committee of Section C draw the attention of Council to the report of their research committee on climatic change, and request them to take such steps as they think fit to implement the suggestions contained therein.

### *From Section G (Engineering).*

The members of Section G desire to call the attention of the Association to the manner in which applications of science to industry are impeded by the present unsatisfactory legal procedure in connection with patent actions. They recommend that a committee be established to collect information in this matter and to frame possible improvements in procedure in technical cases having particularly in mind improved means whereby issues can be more expeditiously examined in the light of technical knowledge and summarised for submission to the judge.

### *From the Conference of Delegates of Corresponding Societies.*

Resolved : to request the Council of the British Association to bring to the notice of the respective Councils for the Preservation of Rural England, Scotland, and Wales the increasing menace to health and amenity, of rubbish



dumping in places of natural beauty and scientific interest ; and to request the said Councils to make representation to the responsible administrative authorities concerned with a view to its mitigation.

*From the Conference of Delegates of Corresponding Societies, supported  
by Sections C, D, E, K.*

Resolved : to request the Council of the British Association to support the Council for the Preservation of Rural England in its endeavour to stimulate His Majesty's Government to consider and take action upon the Report of the Government Committee on National Parks.



10 FEB 1937

# British Association for the Advancement of Science.

BLACKPOOL : 1936

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THE PRESIDENTIAL ADDRESS

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## THE IMPACT OF SCIENCE UPON SOCIETY

BY

SIR JOSIAH STAMP, G.C.B., G.B.E., LL.D., Sc.D., D.Sc., F.B.A.  
PRESIDENT OF THE ASSOCIATION.

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DURING the past year we have had to mourn the loss of our Patron, King George V, but to rejoice in the honour done us by His Majesty King Edward VIII, himself our most illustrious past President, in taking that office.

Since the beginning of this century the British Association has, till now, added only one new place of meeting in this country to its list. Blackpool can certainly do for science in the North all that Bournemouth achieved in the South : give our record new vigour and itself a new friend.

The reactions of society to science have haunted our presidential addresses with various misgivings for some years past. In his great centenary address General Smuts, answering the question 'What sort of a world picture is science leading to?' declared that one of the great tasks before the human race is to link up science with ethical values and thus to remove grave dangers threatening our future. For rapid scientific advance confronts a stationary ethical development, and science itself must find its most difficult task in closing a gap which threatens disruption of our civilisation, and must become the most effective drive towards ethical values. In the following year a great Engineer spoke as a disillusioned man, who watched the sweeping pageant of discovery and invention in which he used to take unbounded delight, and concluded by deploring the risk of losing that inestimable blessing, the necessity

of toil and the joy of craftsmanship, declaring that spiritual betterment was necessary to balance the world. Then came the President of the Royal Society, a supreme Biochemist, on the perils of a leisure made by science for a world unready for it, and the necessity for planning future adjustment in social reconstructions. Followed the Astronomer, deploring man's lack of moral self-control; in knowledge man stands on the shoulders of his predecessor, whereas in moral nature they are on the same ground. The wreck of civilisation is to be avoided by more and not by less science. Lastly, the Geologist gloried in the greatest marvel of millions of centuries of development, the brain of man, with a cost in time and energy that shows us to be far from the end of a mighty purpose, and looking forward confidently to that further advance which alone can justify the design and skill lavished on such a task. So the Geologist pleads then for scientific attention to man's mind. He has the same faith in the permanence of man's mind through the infinite range of years

‘ Which oft hath swept this toiling race of men  
And all its laboured monuments away,’

that is shown at the Grand Canyon, where, at the point exposing, in one single view, over a billion and a half years of the world's geological history, a tablet is put to the memory of Stephen Tyng Mather, the founder of the National Park Service, bearing what is surely the most astonishing scientific expression of faith ever so inscribed :

‘ There will *never come an end* to the good that he has done.’

We have been pleading then in turn for ethical values, for spiritual betterment, for right leisure, for moral advance, and for mental development, to co-ordinate change in man himself with every degree of advance in natural science in such a harmony that we may at last call it Progress. This extension of our deeper concern beyond our main concern is not really new, but it has taken a new direction. I find that exactly one hundred years ago there was a full discussion of the moral aspects, a protest that physical science was not indeed, as many alleged, taking up so much of the attention of the public as to arrest its study of the mind, of literature and the arts; and a round declaration that by rescuing scientists from the narrowness of mind which is the consequence of limiting themselves to the details of a single science, the Association was rendering ‘ the prevailing taste of the time more subservient to mental culture.’ A study of these early addresses shows that we are more diffident today in displaying the emotions and ideals by which I do not doubt we are all still really moved. But they also show that we



are preoccupied to-day with some of the results of scientific discovery of which they were certainly then only dimly conscious. A part of that field, which ought itself to become scientific, is my theme to-day.

What do we mean by impact? My subject is *not* the influence or effect of science upon society—too vast, varied and indeterminate for such an occasion. We may consider the position of the average man, along a line of change we call 'progress,' at the beginning of a certain interval of time and at its end. We might then analyse how much is due to a change in the average man himself, his innate physical and mental powers, and how much to other influences, and particularly to science. We may debate whether the distance covered is great or small by some assumed standard, and whether progress has been rapid. We might ask whether the direction has been right, whether he is happier or better—judged again by some accepted standard. But our concern here is with none of these questions. I ask whether the transition has been difficult and distressing, in painful jerks and uprootings, costly, unwilling, or unjust; or whether it has been easy, natural, and undisturbing. Does society make heavy weather of these changes, or does it, as the policeman would say, 'come quietly'? The attitude of mind of our order may be either that change is an interruption of rest and stability, or that rest and stability are a mere pause in a constant process of change. But these alternatives make all the difference to its accommodating mechanisms. In one case there will be well developed tentacles, grappling irons, anchorages, and all the apparatus of security. In the other, society will put on casters and roller bearings, cushions, and all the aids to painless transition. The *impact* of science will be surprising and painful in the one case, and smooth and undamaging in the other. Whatever may be the verdict of the past, is society and its institutions now learning that change is to be a continuous function, and that meeting it requires the development of a technique of its own?

Science itself has usually no immediate impact upon institutions, constitutions and philosophies of government and social relations. But its *effects* on people's numbers, location and habits soon have; and the resistance and repugnance shown by these institutions and constitutions to the changed needs may rebound or react through those effects upon scientific enterprise itself and make it more precarious or more difficult. Thus the effect of applications of electricity and transport improvements is clearly to make the original areal extent of city or provincial governments quite inappropriate, and the division of functions and methods of administration archaic. If these resist change unduly they make it more difficult and frictional, and the applications of science less profitable and less readily

acceptable. Time makes ancient good uncouth. When two bodies are violent or ungainly in impact, both may be damaged. If the written constitution of the United States, devised for the 'horse and buggy' days, still proves not to be amenable to adjustment for such demands, it will be difficult to overstate the repercussion upon economic developments and the scientific enterprise that originates them. Let the Supreme Court Decision of unconstitutionality on the Tennessee Valley experiment in large scale applied science to natural problems on a co-ordinated plan bear witness. Such unnecessary resistance may be responsible for much of what has been aptly called 'the frustration of science.' Avoidable friction in the reception given to scientific discovery not only deprives the community of advantages it might otherwise have enjoyed much earlier, or creates a heavy balance of cost on their adoption; it may also discourage applied science itself, making it a less attractive and worthwhile pursuit. In that sense we are considering also the impact of society upon science. This too is not new. The Association had as one of its first objects 'to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.' The first address ever offered affirmed that the most effectual method of promoting science was the removal of the obstacles opposing its progress, and the President instanced the very serious obstacles in the science of optics due to the regulations relating to the manufacture of glass. To-day perhaps the scientist places more stress upon the failure of governments to encourage, than upon their tendency to discourage. So much then for the *idea* of impact. Is the scientist or inventor responsible for impact, and if not, who is?

Elsewhere I have retouched Jeremy Bentham's poignant picture of the inventor of over a century ago, plans and cap in hand, on the doorstep of the rich or influential, waiting for someone to believe in him. From this type of external 'sport' amongst engineers and scientists came much or most industrial innovation, external to the processes of business. To-day, in the older and applied sciences affecting industry the solo scientist is the exception and, with the large research departments of particular businesses and trade research associations, the picture is quite different—the expenditure higher, but the results much more rapid and numerous even if for a time they may be kept secret. Although records of finished work may be available over the civilised world, there is much overlapping of current work, but the price of this as a whole is a far smaller fraction of the total result, if we omit from our consideration the first magnitude discoveries of epoch-making influence. The industrial community is now far more amenable than hitherto to scientific influence, indeed it is often the instigator in the mass of minor advances. The



new epoch of concerted industrial research dates really from the end of the great war. During all that time I have held some middle position of responsibility between the research laboratories and institutes on the one hand, and the costing and profit and loss accounts on the other, and my impression is that the proportion of work in which the initiation comes from the business end is steadily increasing. In studies of the periods of scientific and industrial gestation respectively, I have elsewhere defined *scientific gestation* as the time elapsing between the first concept of the idea and its public presentation to society in a form substantially that in which it ultimately finds extensive use without important modification; and *industrial gestation* as the period elapsing from this point to the date when in an economic or industrial sense the innovation is effective. Both periods are difficult to determine exactly in practice, but on a broad view, the period of industrial gestation, with which alone I am here concerned, appears to me certainly to have shortened materially, though possibly at greater social cost. It would obviously be so if industry is actively encouraging research. 'Faraday's discoveries came at the beginning of the great steam era, and for fifty years there would have been no difference in transport even if those discoveries had not been made,' for the telegraph was the only material influence upon it, and practical lighting was delayed till 1900.

In nearly every scientific field there is sub-division of labour, and it is rare that the worker who digs out new truth 'at the face,' so to speak, is also responsible for bringing it to the surface for the public use, still less for distributing the new scientific apparatus or ideas broadly, and even less for the profitable exploitation of the whole process. These functions are nearly always distinct, even though they are embraced under the one general popular description: chemist, engineer, etc. But in few cases is it any part of the professional training in the subject itself, to study how new products or processes affect the structure or welfare of society. I have questioned many scientific workers and find them, of course, keenly alive to the positive and direct beneficial effects of their work, but they have rarely any quantitative ideas as to negative, indirect and disturbing consequences. All these discoveries, these scientific infants, duly born and left on the doorstep of society, get taken in and variously cared for, but on no known principle, and with no directions from the progenitors. Nor do the economists usually acknowledge any duty to study this phase, to indicate any series of tests of their value to society, or even of methods and regulation of the optimum rate of introduction of novelty. These things just 'happen' generally under the urge of profit, and of consumers' desire, in free competition, regardless of the worthiness of new



desires against old, or of the shifts of production and, therefore, employment, with their social consequences. The economist rightly studies these when they happen, but he is not dogmatic about them not being allowed to happen at all in just that way on account of the social disturbance or degradation of non-economic values which they may involve. It is truly a 'no-man's land' for it is rarely that the functions of government begin until a vested problem exists. Especially in Britain we do not anticipate—'Don't worry,—it may never happen.' Problems with us are usually called 'academic' until we are 'going down for the third time.' It is a maxim of political expediency not to look too far ahead, for it is declared that one will always provide for the wrong contingency. The national foresight over wireless was exceptional, and it has to be contrasted with the opportunist treatment of the internal combustion engine. In reply, it can, of course, be urged that no one can foresee just how a scientific idea will develop until it is tried out, rough and tumble, in economic society, and to make anticipatory rules may even hinder its development.

It is rightly stated that the training of the scientist includes no awareness of the social consequences of his work, and the training of the statesman and administrator no preparation for the potentiality of rapid scientific advance and drastic adjustment due to it, no prevision of the technical forces which are shaping the society in which he lives. The crucial impact is nobody's business.

When the research worker lifts his attention from his immediate pursuit and contemplates its hinterland, he has three possible areas of thought. He may dwell upon its practical applications and seek to make them as immediate and realistic as possible; moved by the desire not to be merely academic, he may return to his task, to focus his attention primarily on what is likely to be of practical utility, rather than on what is intellectually intriguing. Or he may think of its ultimate social consequences, and speculate on the shifts in demand, the unemployment, the loss of capital, the ultimate raising of the standard of life that may result—in other words, he may engage in economic prevision and social and political planning for the results of his efforts. Or in the third place, he may listen and watch for hints from other fields of scientific study which may react upon his own, and suggest or solve his problems. I do not attempt to give these priority. Economic and political prevision is the most difficult and precarious, because it needs a technique different from his own, and is not given by the light of nature. Specialist scientists have no particular gifts for understanding the institutional processes of social life and the psychology of multiple and mass decisions. It is a tortuous and baffling art to transmute their exact findings into the wills and lives of unscientific millions. But quite a number engage

in the pursuit and have not much greater aptitude as amateur ministers of foresight than statesmen would have in planning research. Fewer are skilled, however, in what should be the most appropriate auxiliary to their work—the synthesising of scientific knowledge. The more penetrating they are in their main pursuits, the less may they absorb through analogy or plain intimation from outside. We constantly hear that the average clinical application lags much farther behind the new resources of diagnosis from the laboratory than circumstances compel. But it may be the other way round. The strongest hint of the presence of a particular factor—a positive element in beri-beri—was given by the clinician to the bio-chemist, who relied entirely on the *absence* of a particular factor, a negative element, no less than fifteen years before the bio-chemist took serious notice, looked for it, and found it. Bacteriology and chemistry await the advance of the bio-chemist before they come effectively to each other's assistance. The cause and prevention of the obstinate degree of maternal mortality are objects pursued *ad hoc*, with hardly a casual glance at the direct appeal of the eugenicist to observe the natural consequences of an improvement in female infant mortality two decades earlier.

I do not then pretend to dogmatise as to how far the scientist should become a social reformer. One physicist welcomes the growing sense of social responsibility, among some scientists at least, for the world the labours of their order have so largely created, though he deplures that in this field they are still utterly unscientific. Then another great authority, Sir Henry Dale, declares that it is the scientists' job to develop their science without consideration of the social uses to which their work might be put.

I have long watched the processes by which the scientific specialist 'makes up his mind' in fields of enquiry outside his own. It seems still a matter for investigation whether the development of a specialist's thinking on balance impairs or improves the powers of general thinking compared with what they might otherwise have been. We do not know the kind or degree of truth that may rest in Anatole France's aphorism: 'The worst of science is, it stops you thinking.' Perhaps this was more subtly expressed in the simpler words of the darkie mother: 'If you haven't an education, you've jest *got* to use yoh brains.'

My own experience is that when the attempt to deal with social consequences is made, we quickly find ourselves either in the field of larger politics debating the merits of the three prevalent forms of state government, or else performing miracles with fancy currencies and their blue prints reminiscent of the chemical engineer.

But there are some essential features of the impact which must be dealt with under any form of society and government and with any



machinery for regulating values. They involve man's abilities, his affections, and his tools, all of which have been brusquely treated in the past, and might be scientifically treated in the future. An industrial civilisation is unthinkable without division and, therefore, specialisation, of labour, and without tools and capital instruments. Then life itself is not much worth living without social ties and the allegiances of place and kin. These three indispensable elements of the good life bring out defensive mechanisms for their protection. No one likes to see a man highly trained for a special service or specially fitted by natural aptitudes cut off from opportunity to use his powers and reduced to the level of an unskilled biped. No one likes to see the results of abstinence and specially directed labour which is embodied in a great machine or factory rendered impotent long before it has given its life's usefulness. Waste of skill and of capital are alike grave faults by which we should judge and condemn an industrial organisation. And since man does not live by bread alone, if a ruthless industrial organisation continually tears up the family from its roots, transferring it without choice, to new surroundings, destroying the ties of kin, home and social life, of educational and recreational environments, it is far from ideal. Human labour can never be indefinitely fluid and transferable in a society that has a soul above consumption of mere commodities. These three obstructions to change are not final and rigid limitations upon it. Men die, their skill and home associations with them. Plant and equipment wear out. Their successor presents a natural opportunity in each of the three cases for the introduction of change in position, in aptitude, in purpose or design, without waste or human distress. The length of working life and the durability of materials mark the natural phase or periodicity of a smoothly changing society—its quanta, so to speak. But the impetus for change or the irritant has no such intervals. It proceeds from various causes: varying harvests, changes in natural forces; changing human desires and fashions; differences in the rate of growth of population in its different parts; the collective psychological errors of optimism and pessimism in business in an individualistic society; variations in gold supplies and credit policies based thereon. All or any of these, without invoking any disturbances from the impact of scientific discovery, would serve to make adjustments necessary outside the natural phases to which I have referred, in a society with parts that are interdependent through division of labour, and localisation of industry, joined by foreign trade and convenient transport. These alone would bring about a changing world with incomplete adaptations, loss of capital, and so-called frictional unemployment. It is easy to exaggerate the adjustment necessary for the addition of invention and science to these causes of change. But with the intensifica-



tion of scientific effort, and the greater sub-division of industry, the possible dislocation becomes more frequent and the ways of meeting such change of greater public importance. This field of inquiry includes widely diverse questions, e.g., patent laws, invention clearing, obsolescence accountancy and costing regulation, taxation adjustments, local rating pooling, trade union regulations, price controls, technical education, age and other discriminations in unemployment relief, transfer bonuses, pension rights, housing facilities, and more selective direction of financial support of intensive scientific research. In this neutral field the specialist scientist and the politician are both amateurs. It is to be covered by each extending his studies, and by specialists who treat impact and change as an area of scientific study.

I do not propose to go over all the ground, so old, so constantly renewed, as to the effect of machinery upon employment. It is known as an historical induction that in the long run, it makes more employment than it destroys, in providing work in making the machinery, in reducing price so that far greater quantities of the commodity concerned may be consumed, and in enabling purchasing power to be diverted to increase other productions. It has even facilitated the creation of a larger population, which in turn has provided the new markets to work off the additional potentiality of the machinery. It does all this in 'the long run,' but man has to live in the short run, and at any given moment there may be such an aggregation of unadjusted 'short runs' as to amount to a real social hardship. Moreover, it comes in this generation to a people made self-conscious by statistical data repeated widespread at frequent intervals, and to a people socially much more sensitive to all individual hardship and vicissitude which is brought about by communal advance.

There are two important aspects of the change induced by science which are insufficiently realised, and which makes a profound difference to the direction of thought and inquiry. The first I will call the 'balance of innovation' and the second the 'safety valve' of population.

The changes brought by science in economic life may be broadly classified as the 'work creators' and the 'work savers.' The latter save time, work, and money by enabling the existing supply of particular commodities to be produced more easily, and therefore at lower cost, and finally at lower prices. People can spend as much money as before upon them and get larger quantities or they can continue to buy their existing requirements at a lower cost. In this second event they 'save money' and their purchasing power is released for other purposes. By a parallel process, producing or labouring power is released through unemployment. The released

working force and released purchasing power can come together again in an *increased* demand for other products which, to this extent, have not been hitherto within effective demand. The supply of this increase may go part or all of the way to absorb the displaced labour. But this process takes time, and the labour displaced is not at once of the right kind nor in the right place. More important, however, is the invention of quite new objects of public demand, which may be desired in addition to the supply of old ones. This brings together released labour and released purchasing power in the most decisive way. The most orderly and least disturbing phases of progress will be found when these two types of innovation are reasonably balanced. Of course, few new objects of purchasing ambition are entirely additive; most of them displace some other existing supplies. Artificial silk displaces some cotton consumption, radio may displace some types of musical instruments. Recently the German production of pianos and guitars has been at a very low percentage of capacity, and part of this has been made good by the demand for radio sets. The dislocations caused by labour-saving machinery can most easily be made good by a due *balance* of new labour creating commodities.

A natural increase of population is the best shock absorber that the community can possess, especially if accompanied by an extension of territory such as the United States enjoyed in the constant westward movement of the frontier in the nineteenth century, or Britain in the period of overseas emigration. A moment's reflection will show why this is the case. Assume that 1,000,000 units of a commodity are made by 100,000 men, and that there is an increase of population of 2 per cent. per annum, so that in five years 1,100,000 units will be consumed and employ 110,000 men. Now assume the introduction of a new invention which enables 1,100,000 units to be made by 100,000 men. There will be no displacement of existing labour, but only a redirection of new and potential labour from that industry to other fields. Again, a considerable reduction in demand *per head* can be sustained without dislocation, if the actual aggregate of production demanded is maintained by increasing numbers. The affected industry can remain static and need not become derelict. New entrants to industry will be directed to those points where purchasing power, released through labour-saving devices, is creating new opportunity with new products. New capital is also naturally directed into the new channels, instead of into additions to the old industry.

Now the problem before all western industrial countries is the fact that their populations are shortly becoming stationary (and then will begin to decline noticeably) and this safety valve of increasing population will no longer be available. Every transfer of *per capita*



purchasing power to new directions must then be a definite deduction from the old directions, no longer made good by the steady increase in the numbers demanding less per head from those old sources. The impact of science upon a stationary population is likely, *ceteris paribus*, to be much more severely felt than upon a growing population, because the changes of direction cannot be absorbed by the newly directed workers. Of course, the effects of a static population can be mitigated if the *per capita* income is increasing, because a new direction of demand can be satisfied out of the additional purchasing power without disturbing the original directions of demand provided by the original purchasing power. But the change from a growing to a static or declining population is only one type of difficulty. While the aggregate is altering but slowly, the parts may be changing rapidly. Thus, in this country 40.4 millions in 1937 becomes 40.6 in 1942, 40 in 1947, 39.8 millions in 1952, 38.9 in 1957 and 37.5 in 1962. But the children aged 16—which I take because of its influence on schools, teaching and industrial entry—have been estimated, taking those in 1937 as 100, to be 85 in 1942, 73 in 1952 and 62 in 1962. A fall of this magnitude means that industries and institutions dependent upon the present numbers must not be merely static but actually regressive. On the other hand, the old people from 65 to 74 will increase in this ratio—100, 113, 127, and 133. These problems of static populations at home are accentuated by the possibility of a similar tendency abroad, and need thought in advance. The Australian farmer is more affected by the British conditions of population than by his own.

We have thus the first difficulty, that of a static total demand, the second, that the safety valve of new industrial entrants is becoming smaller, but a third difficulty comes from the present tendency of that class. A stationary elderly population must be very inflexible to change, but a stream of new young life, even if it is to be smaller, would give the opportunity for just that change of direction, in training and mobility, which society needs. But unfortunately, in practice this does not now seem to be very adaptable. For we learn from certain Unemployment Insurance areas that while the older people will willingly take jobs at wages a few shillings in excess of the unemployment relief, the younger men are more difficult. For every one that will accept training under good conditions to suit them for eligible work, ten may refuse, and the number who will not go any distance to take work at good wages is also in excess of those who do. Attachment to place for older people is understandable, and has been accentuated by housing difficulties—one learns of miners unemployed in a village where the prospects of the pit reopening are negligible, while at the same time, only twenty miles away new miners are being created by attraction from agriculture to more extended workings in



their area. The very social machinery which is set up to facilitate change or to soften dislocation, aggravates the evil. The first two difficulties are unalterable. This third difficulty is a subject for scientific examination.

So much for the effect of change of any kind upon employment. Now let us narrow this to scientific changes. At any given moment the impact of science is always causing some unemployment, but at that same time the constructive additional employment following upon past expired impacts is being enjoyed. But it is easy to exaggerate the amount of the balance of net technological unemployment. For industrial disequilibrium arises in many ways, having nothing whatever to do with science. Changes of fashion, exhaustion of resources, differential growth in population, changing customs and tariffs, the psychological booms and depressions of trade through monetary and other causes, all disturb equilibrium, and, therefore, contract and expand employment in particular places. Our analytical knowledge of unemployment is bringing home the fact that, like capital accumulation, it is the result of many forces. A recent official report indicated that a quite unexpected amount or percentage of unemployment would be present even in boom times. We know already that there may be a shortage of required labour in a district where there is an 8 or 10 per cent. figure of unemployment. So, in this country there may well be a million unemployed in what we should call good times—it is part of the price we pay for the high standard of life secured by those who retain employment. For a level of real wage may be high enough to prevent every one being employable at that wage—though that is by no means the whole economic story of unemployment. Of this number probably 200,000 would be practically unemployable on any ordinary basis—the ‘hard core’ as it is called. Perhaps seven or eight hundred thousand from the perpetual body, changing incessantly as to its unit composition, and consisting of workers undergoing transition from job to job, from place to place, from industry to industry, with seasonal occupations—the elements of ‘frictional’ unemployment through different causes. Out of this number, I should hazard that not more than 250,000 would be unemployed through the particular disturbing element of net scientific innovation. This is the maximum charge that should be laid at the door of science, except in special times, such as after a war, when the ordinary application of new scientific ideas day by day has been delayed, and all the postponed changes tend to come with a rush. At any given moment, of course, the technological unemployment that could be computed from the potentiality of new processes over displaced ones, appears to be much greater. But such figures are *gross*, and from them must be deducted all recent employment in producing new things or larger production

of old things, due to science. If we are presenting science with part of the responsible account of frictional unemployment at any moment, it will be the total technological reduction due to new processes and displacement due to altered directions of demand, less the total new employment created by new objects of demand. This has to be remembered when we are being frightened by the new machine that does with one man what formerly engaged ten. Perhaps birth control for people demands ultimately birth control for their impedimenta.

The rate of introduction of new methods and the consequent impact upon employment may depend upon the size and character of the business unit. If all the producing plants for a particular market are under one control, or under a co-ordinated arrangement, the rate of introduction of a new labour-saving device will be governed by a simple consideration. It can be introduced with each renewal programme for each replacement of an obsolete unit, and therefore without waste of capital through premature obsolescence. But this applies only to small advantages. If the advantages are large, the difference in working costs for a given production between the old and the new types may be so considerable that it will meet not only all charges for the new capital, but also amortize the wasted life of the assets displaced before they are worn out. In neither case then is there any waste of capital, and the absorption of the new idea is orderly in time. But it is quite otherwise if the units are in different ownerships. Excess capacity can quickly result from new ideas. A new ship or hotel or vehicle with the latest attractions of scientific invention, quite marginal in their character, may obtain the bulk of the custom, and render half empty and, therefore, half obsolete, a unit built only a year before. The old unit has to compete by lower prices, and make smaller profits. The newer unit is called upon to bear no burdens in aid of the reduced capital values of the old. It may be that the enhanced profits of the one added to the reduced profits of the other make an average return upon capital not far different from the average that would result in a community where orderly introduction on a renewal basis is the rule. Or perhaps the community gets some of its novelties rather earlier under competitive conditions and pays a higher rate of interest for them as a net cover for the risks of obsolescence. Waste of capital would be at a minimum if the 'physical' life before wearing out were as short as the 'social' life of the machine. To make a thing so well that it will last 'for ever' is nothing to boast about if it will be out of fashion in a few years.

Scientists often look at the problem of practical application as if getting it as rapidly as possible were the only factor to be considered in social advantage, and this difference in the position of monopoly or single management in their ability to 'hold up' new ideas is



treated as a frustration in itself. Thus it has been said 'the danger of obsolescence is a great preventative of fundamental applications to science. Large firms tend to be excessively rigid in the structures of production.' Supposing that the obsolescence in question is a real factor of cost, it would fall to be reckoned with in the computation for transition, whatever the form of society, and even if the personal 'profit' incentive were inoperative. It cannot be spirited away. A customary or compulsory loading of costs for short life obsolescence would retard uneconomically rapid competition of novelties and could be scientifically explored.

Now let us look at displaced labour and the costs of it. If the effect of diversion of demand through invention is to reduce the scope or output of particular industries or concerns in private management, they have no option but to reduce staff. If the pressure is not too great, or the change too rapid, this does not necessarily result in dismissals, for the contraction of numbers may be made by not filling up, with young people, the vacancies caused by natural wastage, through death and retirement. But where dismissals are inevitable, re-engagements may take place quickly in the competing industries, otherwise unemployment ensues. Any resulting burden does not fall upon the contracting and unprofitable industry—it has troubles enough of its own already. Nor is it put upon the new and rising industry, which is attracting to itself the transferred profits. In the abstract, it might be deemed proper that before the net gains of such an industry are computed or enjoyed it should bear the burdens of the social dislocation it causes by its intrusion into society. In practice, it would be difficult to assess its liability under this head, and in fact even if it could be determined, new industries have so many pioneer efforts and losses, so many failures, so many superseded beginnings, that it might well be bad social policy to put this burden upon them, for they would be discouraged from starting at all, if they had to face the prospect of such an overhead cost whatever their results. It would, of course, be theoretically possible to put a special levy on those new industries that turned out to be profitable, and to use it to relieve the social charges of dislocation of labour. But much the same argument could be used for the relief of obsolescence of capital. The distinction would, however, be that in the case of the capital it could be urged that the investor should have been wide enough awake to see the possibilities of the rival, whereas the worker, induced to take up employment in such a superseded industry, was a victim, and could not be expected to avoid it by prevision. In any case, the prevailing sentiment is rather to encourage developing industries, than to put special burdens upon them, in order that the fruits of science may be effectively enjoyed by society with as little delay as possible.



In the upshot, therefore, the injuries to labour, though not to capital, are regarded as equitably a charge to be borne by society in general through taxation, and to be put upon neither the causing nor the suffering business unit.

And it may well be assumed that taken throughout, the gains of society as a whole from the rapid advance are ample enough to cover a charge for consequential damages. But society is not consciously doing anything to regulate the rate of change to an optimum point in the net balance between gain and damage.

The willingness of society to accept this burden is probably mainly due to the difficulty of fairly placing it, for we find that when it *can* actually be isolated and the community happens fortuitously to have a control, or the workers a power to induce, it will be thrown, not upon the attacking industry, if I may so call it, but upon the defender. Thus in the United States recently, the price of consent to co-ordinating schemes made for the railroads to reduce operating expenses, has been an agreement on this very point. If staff is dismissed, as it was on a large scale in the depression, because of fewer operations and less stock in consequence of reduced carriage through the smaller volume of trade, or through road and sea competition, no attempt is made to put any of the social cost upon the railroads, and the dismissed staff become part of the general unemployed. But if the self-defence of the companies against competition takes the form of co-operation with each other to reduce operations and stock and, therefore, costs, any resultant dismissals are made a first charge upon them. The agreement is elaborate, and has the effect of preventing any adjustments which an ordinary business might readily make when it throws the burden on society, unless those adjustments yield a margin of advantage large enough to pay for their particular special effects. Thus the rapidity of adjustment to new conditions, not to meet the case of higher profits to be made at the expense of workers, but rather to obviate losses through new competition, is materially affected, and a brake is put upon the mechanism of equilibrium in this industry which does not exist in its rivals, or in any others where the power exists to throw it upon the community. A similar provision exists in the Argentine, and it is imposed by Act of Parliament in Canada, but as one of the concerns is nationally owned, and the current losses fall upon the national budget, its charge is really socially borne in the end. In this country such provisions were part of the amalgamation project of 1923, and of the formation of a single transport authority in London in 1933 and, therefore, did not arise through steps taken to meet new factors of competition. But the opportunity for their imposition came when rights to road powers and rights to pooling arrangements were sought by the railways—both of them adjusting mechan-

isms to minimise the losses due to the impact of new invention—and this was clearly a specialised case of keeping the burdens off society. In the case of the electricity supply amalgamation of 1933, brought about for positive advantages rather than in defence against competition, similar provision was made, and parliamentary powers for transfers to gas and water undertakings, also not defensive against innovation, have been accompanied by this obligation. In the case of such uncontrolled businesses as Imperial Chemicals and Shell Mex, rationalising to secure greater profits, rather than fighting rearguard actions to prevent losses, obligations to deal with redundancies had been voluntarily assumed. In such cases the public obloquy of big business operations inimical to society can be a negative inducement, but some freedom from radical competition in prices provides a positive power to assume the burden initially, and pass it forward through price to consumers, rather than back against shareholders. The third case, however, of making it a net charge on the improved profits, is quite an adequate outlet. If the principle of putting this particular obstacle in the way of adjustments to meet new competition (as distinct from increasing profits) is socially and ethically correct, it is doubtful whether it is wisely confined to cases where there is quite fortuitously a strategic control by public will.

It will be clear that the difference between the introduction by purely competitive elements involving premature obsolescence and unemployment, and by delayed action, is a cost to society for a greater promptness of accessibility to novelty. The two elements of capital and labour put out of action, would have supplied society with an extra quantity of existing classes of goods, but society prefers to forgo that for the privilege of an earlier anticipation of new things. I estimate this price to be of the order of three per cent. of the annual national income. But when we speak of social advantage, on balance, outweighing social cost, we dare not be so simple in practice. If the aggregate individual advantage of adopting some novelty is 100x and the social cost in sustaining the consequential unemployed is 90x, it does not follow that it is a justifiable bargain for society. The money cost is based on an economic minimum for important reasons of social repercussions. But the moral effects of unemployment upon the character and happiness of the individual escape this equation altogether, and are so great that we must pause upon the figures. What shall it profit a civilisation if it gain the whole world of innovation and its victims lose their souls?

So far I have treated the problem of innovation as one of uneconomic rapidity. But there is another side—that of improvident tardiness. Enormous potentialities are seen by scientists waiting



for adoption for human benefit, under a form of society quicker to realise their advantage, readier to raise the capital required, readier to pay any price for dislocation and to adjust the framework of society accordingly. A formidable list of these potentialities can be prepared, and there is little doubt that with a mentality adjusted for change, society could advance much more rapidly. But there is a real distinction between the methods of adopting whatever it is decided to adopt, and the larger question of a more thoroughgoing adoption. In proportion as we can improve the impact of the present amount of innovation, we can face the problem of a larger amount or faster rate. Unless most scientific discoveries happen to come within the scope of the profit motive, and it is worth someone's while to supply them to the community, or unless the community can be made sufficiently scientifically minded to include this particular demand among their general commercial demands, or in substitution for others, nothing happens—the potential never becomes actual. It has been computed that a benevolent dictator could at a relatively small expense, by applying our modern knowledge of diet, add some two inches to the average stature and seven or eight pounds to the average weight of the general population, besides enormously increasing their resistance to disease. But dictators have disadvantages, and most people prefer to govern their own lives indifferently, rather than to be ideal mammals under orders. To raise their own standard of scientific appreciation of facts is the better course, if it is not utopian. It has been clear for long enough that a diversion of part of the average family budget expenditure from alcohol to milk would be of great advantage. But it has not happened. If the individual realised the fact, it certainly might happen. It is ironically remarked that the giving of free milk to necessitous children, with all the net social gain that it may bring about, has not been a considered social action for its own sake, but only the by-product emergency of commercial pressure—not done at the instance of the Ministry of Health or the Board of Education, but to please the Milk Marketing Board by reducing the surplus stocks of milk in the interests of the producer!

Scientists see very clearly how, if politicians were more intelligent, if business men were more disinterested and had more social responsibility, if governments were more fearless, far-sighted, and flexible, our knowledge could be more fully and quickly used to the great advantage of the standard of life and health—the long lag could be avoided, and we should work for social ends. It means, says Mr. Julian Huxley, 'the replacement of the present socially irresponsible financial control by socially responsible planning bodies.' Also, it obviously involves very considerable alterations in the structure and objectives of society, and in the occupations and pre-occupations



of its individuals. Now a careful study of the literature of planning shows that it deals mainly with planning the known, and hardly at all with planning for changes in the known. Although it contemplates 'planned' research, it does not generally provide for introducing the results of new research into the plan, and for dealing with the actual *impact*—the unemployment, redirection of skill, and location, and the breaking of sentimental ties that distinguish men from robots. It seems to have not many more expedients for this human problem than our quasi-individualist society with its alleged irresponsibility. It also tends to assume that we can tell in advance what will succeed in public demand and what will be superseded. There is nothing more difficult, and the attempt to judge correctly under the intellectual stimulus of high profits and risk of great losses is at least as likely to succeed as the less personally vital decision on a committee. Would a planning committee, for example, planning a new hotel in 1904, have known any better than capitalist prevision that the fifteen bathrooms then considered adequate for social demand, ought really to have been ten times that number if the hotel was not to be considered obsolete thirty years later? Prevision thought of in terms of hindsight is easy, and few scientists have enjoyed the responsibility of making practical decisions as to what the public will want far ahead. They, therefore, tend to think of prevision in terms of knowledge and appreciation of particular scientific possibilities, whereas it involves unknown demand schedules, the unceasing baffling principle of substitution, the inertia of institutions, the crusts of tradition and the queer incalculability of mass mind. Of course, in a world where people go where they are told, when they are told, do what they are instructed to do, accept the reward they are allotted, consume what is provided for them, and what is manifestly so scientifically 'good for them' these difficulties need not arise. The human problem will then be the 'Impact of Planning.' I am not here examining the economics of planning as such, but only indicating that it does not provide automatically the secret of correct prevision in scientific innovation. When correct prevision is possible a committee can aim at planning with a minimum disturbance and wastage (and has the advantage over individuals acting competitively), but for such innovation as proves to be necessary it does not obviate the human disturbance or radically change its character. The parts of human life are co-ordinated and some are more capable of quick alteration than others, while all are mutually involved. One may consider the analogy of a railway system which has evolved, partly empirically and partly consciously, as a co-ordinated whole. Suddenly the customary speed is radically changed, and then it may be that all the factors are inappropriate—distance between signals, braking power, radius of

curves, camber or super-elevation, angles of crossings, bridge stresses. The harmony has been destroyed. Especially may this be the case if the new factor applies to some units only, and not to all, when the potential density of traffic may be actually lessened. The analogy for the social system is obvious, and its form of government matters little for the presence of the problem, though it may be important in the handling of it.

I have spoken as though the normal span of life of men and machinery themselves provides a phase to which scientific advance might be adjusted for a completely smooth social advance. But this would be to ignore customs and institutions, even as we see in Federal America, Australia and Canada, constitutions which lengthen that phase and make it less amenable as a natural transition. At one time we relied on these to bring about the economic adjustment necessary. But technical changes take place so rapidly that such forces work far too slowly to make the required adaptation. Habits and customs are too resistant to change in most national societies to bring about radical institutional changes with rapidity, and we patch with new institutions and rules to alleviate the effects rather than remove the causes of maladjustments. The twenty mile speed limit long outstayed its fitness, and old building restrictions remained to hamper progress. Edison is reported to have said that it takes twenty-five years to get an idea into the American mind. The Webbs have given me a modal period of nineteen years from the time when an idea comes up as a practical proposition from a 'dangerous' left wing to the date when it is effectively enacted by the moderate or 'safe' progressive party. This period of political gestation may be a function of human psychology or of social structure. We do not know how ideas from a point of entry, permeate, infiltrate or saturate society, following the analogues of conduction, convection, or lines of magnetic force.

Our attitude of mind is still to regard change as the exceptional, and rest as the normal. This comes from centuries of tradition and experience, which have given us a tradition that each generation will substantially live amid the conditions governing the lives of its fathers, and transmit those conditions to the succeeding generation. As Whitehead says: 'we are living in the first period of human history for which this assumption is false.' As the time span of important change was considerably longer than that of a single human life, we enjoyed the illusion of fixed conditions. Now the time span is much shorter, and we must learn to experience change ourselves.

I have so far discussed modification of impact to meet the nature of man. Now we must consider modifying the nature of man to meet impact.



Sociologists refer to our 'cultural lags' when some of the phases of our social life change more quickly than others and thus get out of gear and cause maladjustments. Not sufficient harm is done to strike the imagination when the change is a slow one, and all the contexts of law, ethics, economic relations and educational ideals tend towards harmony and co-ordination. We can even tolerate by our conventions, gaps between them when preachers and publicists can derive certain amusement and profit from pointing out our inconsistencies. But when things are moving very rapidly, these lags become important; the concepts of theology and ethics, the tradition of the law, all tend to lag seriously behind changes brought about through science, technical affairs and general economic life. Some hold that part of our present derangement is due to the lack of harmony between these different phases—the law and governmental forms constitutionally clearly lag behind even economic developments as impelled by scientific discovery. An acute American observer has said that 'the causes of the greatest economic evils of to-day are to be found in the recent great multiplication of interferences by Government with the functioning of the markets, under the influence of antiquated doctrines growing out of conditions of far more primitive economic life.' It would be, perhaps, truer to say that we are becoming 'stability conscious' and setting greater store, on humanitarian grounds, by the evil effects of instability.

In the United States it would be difficult to find, except theoretically in the President, any actual person, or instrument in the Constitution, having any responsibility for looking at the picture of the country as a whole, and there is certainly none for making a co-ordinated plan. Indeed, in democracy, it is difficult to conceive it, because the man in public life is under continual pressure of particular groups, and so long as he has his electoral position to consider, he cannot put the general picture of progress in the forefront. Whitehead declared that when an adequate routine, the aim of every social system, is established, intelligence vanishes and the system is maintained by a co-ordination of conditioned reflexes. Specialised training alone is necessary. No one, from President to miner, need understand the system as a whole.

The price of pace is peace. Man must move by stages in which he enjoys for a space a settled idea, and thus there must always be something which is rather delayed in its introduction, and the source of sectional scientific scorn. If every day is 'moving' day, man must live in a constant muddle, and create that very fidget and unrest of mind which is the negation of happiness. Always 'jam to-morrow'—the to-morrow that 'never comes.' If we must have quanta of stages, the question is their optimum length and character, not merely the regulation of industry and innovation to their tempo,



but the education of man and society to pulse in the same rhythmic wavelength or its harmonic.

In some ways we are so obsessed with the delight and advantage of discovery of new things that we have no proportionate regard for the problems of arrangement and absorption of the things discovered. We are like a contractor who has too many men bringing materials on to the site, and not enough men to erect the buildings with them. In other words, if a wise central direction were properly allocating research workers to the greatest marginal advantage, it would make some important transfers. There is not too much being devoted to research in physics and chemistry, as modifying industry, but there is too much relatively to the research upon the things they affect, in physiology, psychology, economics, sociology. We have not begun to secure an optimum balance. Additional financial resources should be applied more to the biological and human sciences than to the applied physical sciences, or possibly, if resources are limited, a transfer ought to be made from one to the other.

Apart from the superior tone sometimes adopted by 'pure science' towards its own applications, scientific snobbery extends to poor relations. Many of the hard-boiled experimental scientists in the older and so productive fields, look askance at the newer borderline sciences of genetics, eugenics and human heredity, psychology, education, and sociology, the terrain of so much serious work but also the happy hunting ground of 'viewey' cranks and faddists. Here the academic soloist is still essential, and he has no great context of concerted work into which to fit his own. But unless progress is made in these fields which is comparable with the golden ages of discovery in physics and chemistry, we are producing progressively more problems for society than we are solving. A committee of population experts has recently found that the expenditure on the natural sciences is some eight to ten times greater than that on social sciences. There is hardly any money at all available for their programme of research into the immense and vital problems of population in all its qualitative and quantitative bearings. An attack all along the front from politics and education to genetics and human heredity is long overdue. Leisure itself is an almost unexplored field scientifically. For we cannot depend wholly on a hit and miss process of personal adaptation, great though this may be. There must be optimal lines of change which are scientifically determinable. We have seen in a few years that the human or social temperament has a much wider range of tolerance than we had supposed. We can take several popular examples. The reaction to altered speed is prominent. In the *Creevey Papers*, it is recorded that the Knowsley party accomplished 23 miles per hour on the railway, and recorded it as 'frightful—impossible to divest yourself of the notion

of instant death—it gave me a headache which has not left me yet—some damnable thing must come of it. I am glad to have seen this miracle, but quite satisfied with my first achievement being my last.’ In the British Association meeting for 1836, an address on Railway Speeds prophesied that some day 50 miles an hour might be possible. Forty years ago we may remember that a cyclist doing 15 to 18 miles an hour was a ‘scorcher’ and a public danger. Twenty-five years ago, 30 miles an hour in motoring was an almost unhealthy and hardly bearable pace. To-day the fifties and sixties are easily borne, both by passenger and looker on. Aeroplane speeds are differently judged, but at any rate represent an extension of the tolerance. Direct taxation thirty years ago in relation to its effect on individual effort and action seemed to reach a breaking-point and was regarded as psychologically unbearable at levels which to-day are merely amusing. The copious protection of women’s dress then would have looked upon to-day’s rationality as suicidal lunacy. One hesitates to say, therefore, that resistances to scientific changes will be primarily in the difficulty of mental and physical adjustments. But there can be little doubt that with the right applications of experimental psychology and adjusted education, the mind of man would be still more adaptable. Unfortunately, we do not know whether education as an acquired characteristic is in any degree inheritable, and whether increasing educability of the mass is a mere dream, so that we are committed to a sisyphean task in each generation. Nor do we know whether this aspect is affected by the induced sterility of the age. It may not be a problem of changing the same man in his lifetime, but of making a larger difference between father and son. The latest teachings of geneticists hold out prospects for the future of man which we should like to find within our present grasp, and recent successful experiments with mammals in parthenogenesis and euteleogenesis bear some inscrutable expression which may be either the assurance of new hope for mankind or a devil’s grin of decadence.

What is economics doing in this kaleidoscope ?

The body of doctrine which was a satisfactory analysis of society twenty-five years ago is no longer adequate, for its basic postulates are being rapidly changed. It confined itself then to the actual world it knew and did not elaborate theoretical systems on different bases which might never exist. It is, therefore, now engaged in profoundly modifying the old structures to meet these new conditions. Formerly it assumed, quite properly, a considerable degree of fluid or competitive adjustment in the response of factors of production to the stimulus or operation of price, which was really a theory of value-equilibrium. Wherever equilibrium was disturbed, the disturbance released forces tending to restore it.



To-day many of the factors formerly free are relatively fixed, such as wage levels, prices, market quotas, and when an external impact at some point strikes the organism, instead of the effect being absorbed throughout the system by adjustments of all the parts, it now finds the shock evaded or transmitted by many of them, leaving the effects to be felt most severely at the few remaining points of free movement or accommodation. Unemployment is one of these. The extent to which this fact throws a breaking strain upon those remaining free points is not completely analysed, and the new economics of imperfect competition is not fully written out or absorbed. The delicate mechanism of price adjustment with the so-called law of supply and demand governed the whole movement, but with forcible fixation of certain price elements consequences arise in unexpected and remote quarters. Moreover, the search for a communally planned system to secure freedom from maladjustments involves a new economics in which the central test of price must be superseded by a statistical mechanism and a calculus of costs which has not yet been satisfactorily worked out for a community retaining *some* freedom of individual action and choice. The old international currency equilibrated world forces and worked its way into internal conditions in order to do so. But the modern attempt to prevent any internal effect of changes in international trade, or to counteract them, and the choice of internal price stability at all costs against variable international economic equations, has set economic science a new structure to build out of old materials. At this moment when elasticity is most wanted, stability leading to rigidity becomes a fetish. The aftermath of war is the impossibility of organising society for peace.

The impact of economic science upon society to-day is intense and confusing, because, addressing itself to the logic of various sets of conditions as the likely or necessary ones according to its exponents' predilections, it speaks with several voices, and the public are bewildered. Unlike their claims upon physics and mathematics, since it is dealing with money, wages, and employment, the things of everyday, they have a natural feeling that it ought to be easily understandable and its truth recognisable. Balfour once said, in reference to Kant, 'Most people prefer a problem which they cannot explain, to an explanation which they cannot understand.' But in the past twenty years, the business world and the public have become economics-conscious, and dabble daily in index numbers of all kinds, and the paraphernalia of foreign exchange and statistics of economic life. The relativity of economic principle to national psychology baffles the economists themselves, for it can be said truly at one and the same time, for example, that confidence will be best secured by balancing the Budget, and by not balancing



it, according to public mentality. The economics of a community not economically self-conscious are quite different from those of a people who watch every sign and act accordingly. Thus the common notion that economics should be judged by its ability to forecast (especially to a particular date) is quite fallacious, for the prophecy, if 'true' and believed, must destroy itself, inasmuch as the economic conduct involved in the forecast is different after the forecast from what it would have been before. The paradox is just here, for example : if a people are told that the peak of prices in a commodity will actually be on June 10, they will all so act that they anticipate the date and destroy it. Economics, thoroughly comprehended, can well foretell the effects of a tendency, but hardly ever the precise date or amount of critical events in those effects. The necessity for a concentration upon new theoretical and analytical analysis, and upon realistic research, is very great. But so also is the need for widespread and popular teaching. For a single chemist or engineer may by his discovery affect the lives of millions who enter into it but do not understand it, whereas a conception in economic life, however brilliant, generally requires the conformity of the understanding and wills of a great number before it can be effective.

But not alone economics : if the impact of science brings certain evils they can only be cured by more science. Ordered knowledge and principles are wanted at every point. Let us glance at three only, in widely different fields : man's work, man's health, man's moral responsibility. The initial impact of new science is in the factory itself. The kind of remedy required here is covered by the work of the National Institute of Industrial Psychology. Some of this improves upon past conditions, some creates the conditions of greater production, but much of it combats the evils arising from new conditions created by modern demands, speed, accuracy and intensity. It invokes the aid of many branches of science. It is the very first point of impact. Yet its finance is left to personal advocacy, and commands not 10 per cent. of the expenditure on research in artificial silk, without which the world was reasonably happy for some centuries. We can judge of the scope of this by the reports of the Industrial Health Research Board. Again, the scientific ancillaries of medicine have made immense strides. Clinical medicine as an art makes tardy, unscientific and halting use of them. The public remain as credulous as ever, their range of gullibility widened with every pseudo-scientific approach. (We do not know what proportion of positive cases can create the illusion of a significant majority in mass psychology, but I suspect that it is often as low as twenty per cent.) For a considerable range of troubles inadequately represented in hospitals, the real experience passes

through the hands of thousands of practitioners, each with too small a sample to be statistically significant, and is, therefore, wasted from a scientific standpoint. Half-verified theories run riot as medical fashions, to peter out gradually in disillusionment. If the scattered cases were all centralised through appropriately drawn case-histories, framed by a more scientifically trained profession, individual idiosyncrasy would cancel out, and mass scrutiny would bring the theories to a critical statistical issue of verification or refutation in a few months. This would be to the advantage of all society, and achieve an even greater boon in suggesting new points for central research.

A suggestion has been made for an inventions clearing house, to 'co-operate the scientific, social and industrial phases of Invention, and to reduce the lag between invention and application' managed by a committee of scientists and a committee of industrialists and bankers. The proposal came to me from New York, but London was to be the home of the organisation, which was to adopt a code of ethics in the interests of inventors, industry and *social progress*. This brings me to my third example, the field of ethics, which needs the toil of new thought. The systems of to-day, evolving over two thousand years, are rooted in individualism and the relations between individuals. But the relations of society to-day are not predominantly individual, for it is permeated through and through with corporate relations of every kind. Each of these works over some delegated area of the individual's choice of action, and evolves a separate code for the appropriate relationship. The assumption that ethical questions are decided by processes which engage the individual's whole ethical personality is no longer even remotely true. The joint stock company may do something, or refrain from doing something, on behalf of its shareholders, which is a limited field of ethics, and may but faintly resemble what they would individually do with all other considerations added to their financial interests. The whole body of ethics needs to be reworked in the light of modern corporate relations, from Church and company, to cadet corps and the League of Nations.

In no case need we glorify change: but true rest may be only ideally controlled motion. The modern poet says:

'The endless cycle of idea and action,  
Endless invention, endless experiment,  
Brings knowledge of motion, but not of stillness.'

But so long as we are to have change—and it seems inevitable—let us master it. T. S. Eliot goes on:

'Where is the wisdom we have lost in knowledge?  
Where is the knowledge we have lost in information?'

My predecessors have spoken of the shortcomings of the active world—to me they are but the fallings short of science. Wherever we look we discover that if we are to avoid trouble we must take trouble—scientific trouble. The duality which puts science and man's other activity in contrasted categories with disharmony to be resolved, gaps to be bridged, is unreal. We are simply beholding ever-extending science too rough round the edges as it grows.

What we have learnt concerning the proper impact of science upon society in the past century is trifling, compared with what we have yet to discover and apply. We have spent much and long upon the science of matter, and the greater our success the greater must be our failure, unless we turn also at long last to an equal advance in the science of man.



## SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCES.

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# TRENDS IN MODERN PHYSICS

ADDRESS BY

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PRESIDENT OF THE SECTION.

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OUR Section has suffered heavy losses in the twelve months that have passed since the Norwich Meeting, and it is fitting that we should here pay due honour to the memories of McLennan, Glazebrook, Petavel and Pearson, who have, each in his own characteristic fashion, played so great a part in the advances made during this century.

The genius and vigour of Sir John McLennan were quick to seize on and to develop those ideas which were fermenting at Cambridge in the last years of the nineteenth century and to impress on them a character peculiarly his own. His energy and versatility are shown equally in his early studies of penetrating radiation, in his discovery of the single line spectrum of zinc and cadmium, in his later work on the spectrum of the aurora and the nature of the famous green line, and in those studies of supraconductivity to which his last years in Toronto were given. His return to England found him unconquerably young in spirit and prepared to play his part in important investigations in radium beam therapy. He presided over the deliberations of this Section at the Liverpool Meeting of 1923, and those of us who were present at that meeting have vivid memories of an address which reviewed some of the major problems of atomic structure—an address which, the latest word on the matter in 1923, reads to-day as an ancient tale. The laboratory at Toronto which bears McLennan's name bears witness also to his genius as a leader of research and to his gifts as administrator and director.

Sir Richard Glazebrook belonged to the elder generation—he presided over Section A so long ago as 1893—and to the last occupied himself with certain aspects of those problems of macroscopic physics which dominated the science of his century. His early papers on the Fresnel wave-surface are admirable examples of accurate work accomplished with the aid of simple apparatus; and his experiments on the relation between the British Association unit of electrical resistance and the absolute unit marked the first step on a lifelong journey. *Felix opportunitate mortis*, illness was spared him, and death laid a kindly hand on his shoulder while he was still in the full tide of mental activity, still pursuing those studies which had been his companions for more than half a century. The National Physical Laboratory, which, opening in 1902 with two departments and a staff of twenty-six, had in ten years expanded to eight

departments and a staff of a hundred and twenty-six, is Glazebrook's enduring monument.

The work of this great laboratory, stimulated by the conditions of the world-war, was further developed by Sir Joseph Petavel; under his guidance the laboratory has steadily grown in prestige and in the range of its activities, which now demand the services of a staff of nearly seven hundred. In the counsels of our Association, Sir Joseph Petavel ranked as an engineer—he presided in 1919 over the work of Section G—but we of this Section are not unmindful of his contributions to physical science: of his studies of the emissivity of platinum at high temperatures, of the effect of pressure on arc-spectra, of his interest in the problem of aeroplane stability.

Genius, both in its creative aspect and on that side which has been condensed by Edison into a whimsical phrase, marked all to which Karl Pearson put his hand. His ordered development of statistical theory wherein new light is shed on the fundamental problems of frequency distribution, correlation, and probable errors, formed a firm foundation for a superstructure impressive in its height and extent; he never lost that early interest in elasticity shown in his completion of Todhunter's massive *History of the Theory of Elasticity*; and his *Grammar of Science*, overlooked by the majority of our present-day physical-philosophers (though there is perceptible a movement in a direction which shows that its thesis is again finding favour), develops a point of view which should not prove unhelpful to the student of to-day who would fain remain a physicist without of necessity becoming a metaphysician.

These men, whose memories we honour to-day, were trained in a tradition which differs *toto coelo* from that in which our present generation lives and moves. It seems, therefore, not unfitting that one of the presidents whom you have honoured by election to this chair should endeavour to put before you a picture which may show something of these changes and tell something of the facts that have caused them—if it be permissible to use a phrase which apparently commits one to a deterministic outlook.

The world-picture of the older generation was, as we look back on it to-day, extraordinarily simple. It is, or has been, the fashion to describe nineteenth-century science as materialistic. There certainly was Buchner, and there was Tyndall's Belfast address. But *Dr. Stoffkraft* had neither a long reign nor an influential following, and we shall be nearer to the truth if we look upon Victorian science as showing a simple realism—the realism of the man in the street—not wholly unrelated to that simple realism of to-day which sees in an alpha-ray track evidence for the existence of an atom of the same order as that furnished by a diffraction photograph (or, for that matter, of our own eyes) for the existence of a star.

That is by no means the whole story, as far as Victorian science is concerned—Karl Pearson tells a very different tale; but more of that later.

What we have learned to call the classic outlook was based on those notions of velocity, acceleration, momentum and force which were first formed into an ordered scheme by the genius of Newton—a scheme



which sufficed to describe, succinctly and clearly, the series of perceptions involved in such phenomena as the motion of a pendulum, a billiard ball, a railway carriage, and (with certain reservations concerning fine points) the complex motions of the bodies of the solar system. The physical science of the eighteenth and nineteenth centuries was occupied in extending and clarifying these concepts, although eighteenth-century science in England was hampered by an excessive devotion to the memory of Newton, which committed the English mathematicians to the fluxional notation. It required the formation of a society at Cambridge 'to inculcate the principles of pure *d*-ism, and to rescue the University from its *dot*-age,' before the British physical school could rival the advances of their continental brethren.

As we have said, the attitude of the physicist to the fundamentals of his science was, in general, naïvely realistic. Mass was quantity of matter, and matter itself was defined as 'that which can be acted upon by, or can exert force,' or alternatively 'that which may have energy communicated to it from other matter.' *Obscurum per obscurius*, with a vengeance!

Quantitatively, mass was defined, following Newton, as the product of volume and density; and even Thomson and Tait are roused to a hint (without attempting to resolve the difficulty) that such a process results in a circular argument, inasmuch as we have no other way of defining density than as the ratio of mass to volume.

Early in the nineteenth century discoveries, mainly in the realm of chemistry, gave fresh interest to atomic doctrines, and the simple concept of the billiard-ball atom proved to be brilliantly successful in explaining old happenings and in predicting new ones. It is not immediately obvious that an extrapolation of those laws which described the motions of bodies of the dimensions of a locomotive or a planet down to bodies of the indescribably minute dimensions given to an atom or molecule is likely to be successful in subsuming certain perceptual events; the extraordinary thing is, not that such an extrapolation should break down somewhere, but that it should have any validity at all. And the triumphs to be put to the credit of the hypothesis are sufficiently remarkable, as any treatise on the kinetic theory of gases will testify.

It is an odd fact that these days of probability and indeterminacy mark a period in which atomic and molecular constants have been evaluated to a degree of accuracy of which electrical standards need hardly be ashamed. And we may perhaps be pardoned a little local patriotism when we remember that a Manchester man, James Prescott Joule, made the first determination of an absolute molecular magnitude—the mean speed of a hydrogen molecule, which he evaluated as 6,055 ft. per second at the freezing point of water. This paper, which was published in 1848, is not the paper which was denied publication *in extenso* by the Royal Society, concerning whose refusal Joule remarked to Schuster, 'I was not surprised. I could imagine these gentlemen in London sitting round a table and saying to each other: "What good can come out of a town where they dine in the middle of the day?"' That particular paper dates back to 1840, and marks an important stage in the



story of nineteenth-century physics, for in it Joule described the experiments on which his famous  $C^2R$  law is based, and enunciated the law.<sup>1</sup> Indeed the story of the identification of heat with energy, in its novelty and the difficulty of its adoption, is as outstanding a feature of nineteenth-century physics as is the story of the equivalence of mass and energy in the physics of the twentieth century.

No survey of the physical science of the last generation would be complete did it contain no reference to radiation and to the nineteenth-century concept of the mechanism by which radiation is conveyed. Despite the difficulty of framing a theory of the ether which should satisfy dynamical laws—‘Why should it?’ we might remark incidentally to-day—the concept of an ether of space was so brilliantly successful in correlating and predicting so many and so diverse phenomena—we need but instance that bending of light round corners which we call diffraction, that alternate heaping up and destruction of light which we term interference, and that remarkable refraction of a ray of light by certain crystals as a cone of rays—as to draw from Lord Kelvin the downright statement, ‘This thing we call the luminiferous ether . . . is the only substance we are confident of in dynamics. One thing we are sure of, and that is the reality and substantiality of the luminiferous ether.’ Strange reading, to-day; and reading which might well introduce a note of hesitation into some of the confident declarations of present-day realities.

Molar mechanics, the billiard-ball atom, the ether: the nineteenth century had built on these apparently stable foundations an immense structure of ordered knowledge. The closing years of the century were fated to show cracks in the superstructure and weaknesses in the foundations. The facts of radio-activity and the discovery of the electron showed that the concept of the atom must increase in complexity were it to remain competent to subsume the additional perceptual facts. And the experimental study of the radiation from a hot body revealed a state of affairs inexplicable on the lines of classical theory. A hot body radiates energy, and if the radiations are passed through a prism they may be drawn out into a spectrum. How is the energy of the radiation distributed between the different wave-lengths of the spectrum? Experiment gives a clear answer to this question, and the undisputed fact is that, if we plot a curve showing values of the energy associated with a certain wave-length as ordinates against the corresponding wave-lengths as abscissæ, we obtain a curve of a cocked-hat shape with a definite maximum of energy associated with a certain wave-length. If we repeat the experiment with the radiating body at a higher temperature, a similar curve is obtained with the maximum shifted into the region of shorter

<sup>1</sup> In this paper, and in a paper published in the *Philosophical Magazine* in 1841, Joule used the term *resistance* in its ordinary electrical sense (‘the resistances of the . . . wires were found to be in the ratio 6 to 5.51’). The term was used by Cavendish (‘therefore resistance is directly as velocity’) in his now famous anticipation of Ohm’s Law in January 1781—though his words were not printed until 1879. Wheatstone is sometimes quoted as an early user of the term in his Bakerian Lecture for 1843. It is all the more curious, then, that the *Shorter Oxford English Dictionary* should give 1860 as the date at which the term was first used in print.

wave-length. What have nineteenth-century theories of radiation to say to this? Their answer is clear, and gives a curve which coincides with the cocked-hat curve in the region of long wave-lengths but exhibits no maximum, and moves completely away from the experimental curve as the wave-length decreases. It was this complete disharmony between classical theory and experimental fact that led Planck, in the last year of the nineteenth century, to supply a solution giving a curve which closely fits the cocked-hat curve, which has revolutionised physical science and which has incidentally provided the language with a new verb, 'to quantise.' What do we mean when we speak, for instance, of quantising energy? *To quantise a physical quantity is to restrict its magnitude to a number of discrete, separated values, which are integral multiples of a certain selected unit.* Planck assumed that a hot body consisted of a number of oscillators which in their simplest form may be conceived as massive particles oscillating in straight lines with definite frequencies, in simple harmonic fashion. The energy of such an oscillator is easily enough calculated, and the drastic assumption made is that the possible values of the energy of the oscillator are to be restricted to a series of integral multiples of a unit which is itself proportional to the frequency, so that the unit may be written as  $hn$ , where  $n$  is the frequency and  $h$  is a constant known as Planck's constant. And energy is emitted in integral bundles or *quanta*, the indivisible unit of measurement having the magnitude  $hn$ .

Turn now to another experiment, quite inexplicable on the lines of the older wave-theory. An insulated negatively-charged plate of zinc, when exposed to ultra-violet light, loses its charge—loses electrons, that is, in terms of our picture. Certain facts emerge from a close study of the experimental conditions. If, for example, the frequency of the light is below a certain threshold value, then, however great the intensity may be, and whatever the length of time of the exposure, the zinc plate keeps its charge. If, however, the frequency is raised above this threshold value the charge begins to leak away *at once*, and this, though the intensity of the incident light be so small that, on the basis of the wave-theory, it would take days to accumulate sufficient energy to release an electron with the kinetic energy which it is observed to possess. Moreover, the rate of emission of electrons increases proportionately with the increase of intensity of illumination. If we take the view that light consists of photons, bundles or quanta of energy each of magnitude  $hn$ , travelling with the velocity of light, then if, say, a surface atom is struck by a photon, and emits an electron which has to do work in freeing itself from the surface, we may equate the sum of this work and the kinetic energy with which the electron leaves the surface to the energy possessed by the original photon. A little consideration will show that this explanation meets observed facts in a way quite impossible to a classical wave-theory.

Here, then, in this so-called photo-electric effect, and in the experimental facts of the distribution of energy in the spectrum, we have two simple happenings which cannot in any way be squared with classical theory. Consider, now, very briefly some of the elementary facts of spectroscopy—another region of physics to which quantum ideas have been applied with brilliant success. We have travelled far to-day from



the primitive concept of the nuclear atom, with its nucleus composed of  $(x + z)$  protons and  $x$  electrons, so that the nuclear charge was  $ze$  ( $e$  being the electronic or protonic charge), and electrical neutrality was assured by assuming that  $z$  satellite-electrons ( $z$  being what is called the atomic number) circulated in orbits around the nucleus.

The inevitable consequences of the existence of such atoms radiating according to classical laws, was an unstable universe in which the satellite-electrons, radiating energy as they revolve, would spiral down towards the nucleus and finally collapse therein. Quantum notions saved the concept, and one of the peaks in the development of twentieth-century physics is the story of the Bohr atom, in which it is assumed that only a restricted number of stable orbits, or states, is possible; that electrons in these orbits do not radiate; that an electron in moving from one orbit to another radiates or absorbs quanta of energy equal to the difference between the energy states of the two orbits, and that the angular momentum is quantised, that is, is restricted to a number of discrete values, the magnitude of the value in the  $N$ th orbit being  $Nh/2\pi$ .

The application of a little simple algebra to the expression of these postulates results in an equation which represents the disposition of the lines in the spectrum of a single-electron atom, such as hydrogen, or ionised helium, with considerable accuracy. The theory is easily extended to elliptic orbits, though here, having to deal with a varying radius vector and varying radial momentum, we have to quantise this latter quantity and two quantum numbers become necessary, the so-called azimuthal quantum number ( $k$ ) which quantises the angular momentum, and what is called the radial quantum number, the sum of the two being set equal to the total quantum number ( $N$ ).

But the theory in this form was quite inadequate to cope with any system more complex than a single electron system. To deal with these more complex systems, quantum notions were extended on quasi-empirical lines and resulted in what may be called a vector model of the atom in which were visualised the possibility of electron and nuclear spins, with further possibilities in the way of quantisation and quantum numbers. If these quantum numbers are shared between the satellite-electrons of an atom in such a way as to agree with an empirical exclusion principle which states that *no two electrons in an atom may have all their quantum numbers identical*, we may arrive at a distribution of the satellite-electrons as regards their energy-levels which gives a model capable of explaining many complex spectroscopic (and other) facts.

But space presses and we must return, in this rapid survey, to a consideration of that dualism of outlook which appeared so early in the story of twentieth-century physics. The discovery of the Compton effect further emphasised this corpuscular aspect of radiation.<sup>2</sup>

<sup>2</sup> When X-rays are scattered by impact with the more lightly bound electrons in an atom, the radiation scattered at an acute angle has a smaller frequency than the frequency of the incident radiation, a simple explanation of the change being at once forthcoming if the problem is treated in the manner of the treatment of the impact of elastic spheres. Thus a light quantum  $hn$  communicates kinetic energy to an electron by impact. The scattered quantum  $hn'$  will have less energy, and hence  $n'$  will be less than  $n$ .



Suppose we carry this dualism into concepts that are fundamentally corpuscular and assert that matter may have a wave aspect? This is the notion put forward by Louis de Broglie, who postulated that, associated with a particle having momentum  $mv$ , there is a wave of wave-length  $\lambda$  given by  $\lambda = h/mv$ . As radiation which shows the fundamental wave-property diffraction also exhibits corpuscular properties, so electrons which are conceived primarily as corpuscular may be expected to exhibit wave-properties; and they do so. If a beam of electrons be passed through thin foil, diffraction phenomena are observed which are perfectly consistent with the wave-length postulated by de Broglie. If, moreover, leaving the sub-atomic world, we deal with *molecular rays* of hydrogen or helium, we may allow them to be reflected from a crystal surface and may observe diffraction phenomena consistent with a de Broglie wave-length of the right magnitude; *and we may collect the reflected waves as an ordinary gas.*

But all this merely emphasises the dualism of the wave and corpuscular aspects of matter—a dualism which is now disappearing under the analysis of the last few years. The analysis, which is essentially mathematical, has introduced the notion of probability into our estimates, say, of position. We describe the wave which accompanies a corpuscle by means of an equation which will contain an expression for the amplitude of the wave; and the amplitude at any point gives us a measure of the probability of finding the corpuscle at that point; if the amplitude vanishes anywhere the probability of finding the corpuscle at that point vanishes also. The concept of an electron as a definite entity at a definite point in space is replaced by a probability pattern which, very dense in a certain locality, rapidly thins as we move away from that locality. In fact, if we fix our attention on the densest part of a given pattern, the probability of finding an electron at a distance of  $10^{-13}$  cm. therefrom becomes vanishingly small, and most of us may be content to use the concept of an electron almost in our accustomed manner, realising that it has become a little fuzzy at the edges.

Despite the impending disappearance of this dualism, the story of the discovery of sub-atomic particles is most easily told in particle fashion. The discovery of the electron is now more than a generation old, as is the discovery of the  $\alpha$ -,  $\beta$ - and  $\gamma$ -rays of radium, and the  $\alpha$ -rays or particles—fast-moving helium nuclei—provided an atomic projectile which in the hands of Rutherford became a most potent weapon for exploring the intricacies of atomic structure.

Electrons,  $\alpha$ -particles and protons are electrical in origin; they may therefore be deflected by electrostatic fields. They move and so constitute an electric current; they may, therefore, be influenced by magnetic fields. Information concerning their charges and masses may therefore be deduced from their behaviour when subjected to such fields. Further, special means have recently been devised for the generation of controlled fields of high potential which may be used to accelerate charged particles subjected to their influence. In this manner it has been found possible to produce swift protons which may be used to bombard various elements. We can in fact now load, aim and discharge our atomic rifle almost at

will, and with very remarkable results. For example, the bombardment of lithium with high velocity protons results in the formation of  $\alpha$ -particles, a process which may be described by saying that the lithium nucleus whose atomic mass-number is 7 when bombarded by a proton whose mass-number is 1, gives rise to two  $\alpha$ -particles, each of mass-number 4.

With this advance in technique has come a corresponding advance in discovery. Thus the bombardment of a light element such as beryllium by  $\alpha$ -particles results in the production of  $\gamma$ -rays together with a radiation which does not ionise the air through which it passes, but may be recognised by its effect on the nuclei which it itself bombards, producing, as it does, ionisation tracks due to the protons expelled from these nuclei. We have to deal, then, with a massive uncharged particle, whose mass may be deduced from a study of the tracks made by the nuclei with which it collides. The mass of the particle is very nearly equal to that of the proton, and it has been called the *neutron*.

For long it has been known that radiation of high penetrating power exists in the atmosphere, a radiation which increases in intensity, that is, in its power to discharge an electroscope, with increasing height. This is the so-called cosmic radiation, which may be assumed to have its origin in interstellar space. Investigations on cosmic radiation, using the Wilson cloud chamber placed in a strong magnetic field, disclosed the fact that when cosmic radiation passed into such a chamber tracks were produced, some curved in one direction, some in the opposite sense. This opposite curvature might be produced by a reversal of the sign of the charge or it might be due to the fact that the particle was moving in a direction opposite to that of its fellows of opposite curvature. It was not difficult to rule out this latter possibility, and we are thus provided with another sub-atomic entity of mass equal to that of the electron, and with a positive charge equal to the electronic charge.

This is the positron.

The identification of heat and energy—a commonplace to-day—was, as we have remarked, not established without difficulty. The twentieth century has seen a possibly more remarkable identification—that of mass and energy—an identification which was made, to within a factor of  $\frac{4}{3}$ , by Hasenöhl and was put forward in its present form in 1905 by Einstein. In this form the energy ( $E$ ) possessed by a mass ( $m$ ) is given by  $E = mc^2$ , where  $c$  is the velocity of light. Increase of mass of a system means increase of energy and conversely. And if mass be destroyed a corresponding amount of energy appears as radiation, if conservation laws hold. These conservation laws have been arrived at from a study of large-scale phenomena, and there is no *a priori* reason why they should be expected to hold when applied to atomic happenings far outside the perceptual scheme of things. Indeed, one is tempted to ask, Why should the concept of energy have any meaning, let alone any validity, when applied to such systems? The necessary and sufficient answer is the pragmatic one.

The possible invalidity of this law of conservation is no new concept. Twelve years ago Bohr and his colleagues put forward a theory in which an atom in an excited state emits radiation continuously, radiation which,



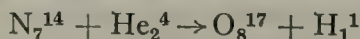
falling on another atom, may make more probable its transition to a higher energy-state. It may be shown that such a theory involves a contradiction of the conservation law in single atomic processes, and experiments carried out to test the theory were best explained on the assumption of conservation.

Recently the supposition of conservation which, as we have seen in the Compton effect, was invoked to explain the changes of frequency involved in the impact of a light quantum and an electron, has again been called into question as a result of experiments made, using modern counting apparatus, on the scattering of  $\gamma$ -rays.

If we apply the conservation laws to nuclear transformations involving protons and neutrons we find that energy is conserved quantitatively, the kinetic energy liberated in a reaction being accurately accounted for by the disappearance of mass which occurs. It is different when we consider atomic processes which involve high speed particles—electrons, say, moving with velocities comparable with that of light. Such processes are not in agreement with the conservation principle, and to pull them into line a new particle, the neutrino, has been introduced, possessing no charge and, if Fermi be right, a negligible mass. Such a particle is not likely to be detected by direct experiment; its principal function is to 'explain' continuous  $\beta$ -ray spectra.

Obviously we have a considerable range of choice in our atomic building materials, and the supposition that the nucleus is composed of protons and electrons in suitable numbers may need modification. The  $\alpha$ -particle, long described as made up of four protons and two electrons, may also be considered as composed of two protons and two neutrons, and there are good reasons for this supposition. But whether the neutron is an elementary particle and the proton may be written as neutron + position, or whether we have more justification for considering the neutron as proton + electron are matters which cannot be discussed in detail here.

One of the most remarkable of the discoveries of recent years has been that of artificial radio-activity. Rutherford's fundamental discovery of 1919 was that transmutations may result from bombardment by  $\alpha$ -particles. Thus, for example, the bombardment of nitrogen by  $\alpha$ -particles results in the transmutation described by the nuclear equation



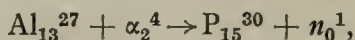
[Read: The nitrogen nucleus of atomic mass-number 14 and atomic number 7 when disintegrated by an  $\alpha$ -particle yields the isotope of oxygen of atomic mass-number 17 and atomic number 8 together with a proton.]

Radio-active bodies, on the other hand, are bodies that break down spontaneously. We have various particles at hand with which to effect transformations by bombardment of nuclei, and for the most part the products resulting from such transmutations are stable. It might, however, happen that a product is produced which spontaneously disintegrates, and we then have the phenomena of artificial radio-activity. The bombardment (e.g.) of aluminium with  $\alpha$ -particles resulted in the

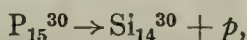


emission of neutrons (the neutron  $n_0^1$  being a particle whose mass-number is unity and nuclear charge zero).

Hence we have



the resulting product being an isotope of phosphorus. But if the bombardment ceases we find that positrons are emitted, the positron ( $p$ ) being a particle of negligible mass and unit positive charge. The isotope of phosphorus produced is in fact radio-active and the nuclear equation gives



the final product being an isotope of silicon. Bombardment by protons, neutrons, or deuterons may produce disintegration products which are unstable; the unstable products resulting from bombardments by  $\alpha$ -particles or deuterons pass over into stable species, sometimes with the emission of positrons, sometimes with the emission of electrons; this latter species of decay—the  $\beta$ -active species—is often accompanied by  $\gamma$ -radiation, so that artificially produced radio-active substances behave in the manner characteristic of natural  $\beta$ -active substances. Neutron bombardment, when it produces radio-elements, produces elements which are  $\beta$ -active.

By nothing has the world-picture of to-day been so transformed from that of a generation—nay of a decade—ago than by the introduction of the uncertainty principle and by its effect on our notions of causality.

It can be shown that of two conjugate quantities—time and energy, or position ( $x$ ) and momentum ( $p$ )—the product of their uncertainties of determination can never be less than the quantum  $h$ . Thus an increase in the accuracy of the determination of one quantity necessitates a corresponding decrease in the accuracy of the conjugate quantity, and in particular the exact determination of one quantity leaves the other completely undetermined. An attempt to determine the position of a particle involves its illumination by light of suitable wave-length, and decrease of the wave-length in order to improve the definition of its position involves an increase in the magnitude of the recoil due to the Compton scattering process.

Following a suggestion of Dr. Flint, let us fix our attention on the quantities position and momentum and consider a co-ordinate system in which momentum ( $p$ ) is plotted along one axis and position ( $x$ ) along the other. The co-ordinate space gives us the possible simultaneous values of  $x$  and  $p$ . Suppose this space divided into rectangles each of area  $h$ . Then the uncertainty principle, which asserts that the product ( $\delta x \delta p$ ) of the uncertainties of the determination of position and momentum can never be less than  $h$ , may be illustrated by resuscitating Maxwell's demon and permitting him to push a point about at will within any one of the rectangles. The movement of the point, that is, the corresponding changes of position and momentum, will not be detected, for they do not correspond to any detectable change in the world of sense.

Unfortunately the word 'indeterminism,' which has other connotations, has become associated with the statement of the principle. Many of us

remember Clerk Maxwell's immortal account of the proceedings of our Section at the Belfast Meeting sixty-two years ago, when Mr. Herbert Spencer regretted 'that so many members of the Section were in the habit of employing the word Force in a sense too limited and definite to be of any use in a complete theory of evolution. He had himself always been careful to preserve that largeness of meaning which was too often lost sight of in elementary works. This was best done by using the word sometimes in one sense and sometimes in another, and in this way he trusted he had made the word occupy a sufficiently large field of thought.'

Is it heresy to suggest that some of us who have sung Canticles in praise of indeterminism and the disappearance of causality have given a similar generousness of meaning to these words?

Similar considerations apply to the term *observable*, which has suffered a sea-change in transference from its ordinary usage in the realms of perception. There is quite as much complicated physical theory lying between the perceptually observable marks on a photographic plate and the inferred frequencies, as there is between similar preceptual observables and the non-observable electron orbit or state which was inferred in order to subsume the perceptual facts. A similar generosity of treatment is accorded to the term *observe* when it is applied to the conceptual experiment for the determination of the position of a particle such as an electron.

Which brings us round to the starting-point of this discourse. Many of us who desire to proceed with our measurements untrammelled by these philosophic doubts have asked if there is not some canon by which the plain man could test his everyday beliefs. I suggest that a starting-point at least to this end is provided by a study of Karl Pearson's work, and that, with certain reservations and additions to the method discussed in the *Grammar of Science*, we may develop a canon which will serve as a guide through the jungle of additional perceptual facts which the physical science of the twentieth century has added to that of its predecessors.<sup>3</sup>

Those who discuss the doctrine of causality do so with little reference to the attitude taken by the philosophers, and it may not be without interest—it certainly has some bearing on present-day thought—to consider the development of the notion of cause since the time of Newton. The views of Locke, Newton's elder contemporary, are clear and simple. He remarks: 'Thus, finding that in that substance which we call *wax*, fluidity, which is a simple idea that was not in it before, is constantly produced by the application of a certain degree of heat, we call the simple idea of heat in relation to fluidity in wax the *cause* of it, and *fluidity* the effect. . . . So that whatever is considered by us to conduce or operate to the producing any particular simple idea, whether substance or mode, which did not before exist, hath thereby in our minds the relation of a cause and so is denominated by us.'

Newton, dominated as he was by the principle of causality and ever

<sup>3</sup> In what follows I have drawn on the material of an article which I wrote some four years ago (*Nature*, vol. 45, 1932, p. 130). See also Broad, *Perception, Physics and Reality*.



searching for a clear physical picture of the results of his investigations, was capable of a philosophic breadth of view which needs surprisingly little modification to-day. He makes, for example, a physical picture of matter as formed in 'solid, massy, hard, impenetrable, moveable particles,' and assumes that they have not only a *Vis Inertiæ*, but are moved by certain active principles, such as gravity. These principles are to be considered 'not as occult qualities . . . but as general Laws of Nature . . . their Truth appearing to us by Phænomena. . . . To tell us that every Species of Things is endowed with an occult specifick Quality by which it acts and produces manifest effects, is to tell us nothing ; but to derive two or three Principles of Motion from Phænomena and afterwards to tell us how the Properties and Actions of all corporeal Things follow from these manifest Principles would be a very great step in Philosophy, though the Causes of those Principles were not yet discovered ; and therefore I scruple not to propose the Principles of Motion above mentioned, they being of very general extent, and leave their Causes to be found out.' Evidently Newton takes the view that we have made an important step forward when we have subsumed a number of perceptual facts under a general formula.

It is to Hume, though he may owe something to Glanvil and other predecessors, that we are indebted for a clearly ordered statement of the experientialist doctrine of causation. The generalisation, for example, that the earth attracts a stone is explained as a generalisation from thousands of observations. 'Adam . . . could not have inferred from the fluidity and transparency of water that it would suffocate him, or from the light and warmth of fire that it would consume him. No object ever discovers by the qualities which appear to the senses, either the causes which produced it or the effects which will arise from it ; nor can our reason, unassisted by experience, ever draw any inference concerning real existence and matter of fact.'

Mill further developed the experientialist doctrine in the statement that the law of causation 'is but the familiar truth that invariability of succession is found by observation to obtain between every fact in nature and some other fact which has preceded it, independently of all considerations respecting the ultimate mode of production of phenomena, and of every other question regarding the nature of things in themselves.' To the doctrine of succession in this simple form the objection has been urged that day may be regarded as the cause of night and conversely. Mill meets this objection by pointing out that invariable sequence does not necessarily involve causation. To involve causation the sequence must not only be invariable but *unconditional*. The day-night sequence is conditional by the sun and so does not conform to this test. 'We may define, therefore, the cause of a phenomenon to be the antecedent, or the concurrence of antecedents, on which it is invariably and unconditionally consequent.'

It is difficult to sum up Pearson's attitude to the problem of causality and to the general problem in a few sentences. Perhaps Kirchhoff's dictum concerning mechanics : 'Die Mechanik ist die Wissenschaft von



der Bewegung ; als ihre Aufgabe bezeichnen wir : die in der Natur vor sich gehenden Bewegung *vollständig* und *auf die einfachste Weise* zu beschreiben,' touches very nearly the root of the matter.

We live, in fact, amid a mass of perceptions ; and it is the business of physical science to correlate, in as simple a fashion as may be, a certain section of these facts. To this end the physicist devises a *conceptual* world of atoms and molecules, from which he builds up a system—a world-picture—of molar masses whose motions correspond to the routine of our sense impressions. Given a frame of reference, we can formulate laws of motion for two isolated particles in a conceptual world which may be summed up in the statement that whatever be the positions and velocities of the particles the ratio of their accelerations is always constant ; this ratio is defined as the inverse mass-ratio of the particles ; and in virtue of this we have the relation that—

$$\text{Mass of } A \times \text{acceleration of } A = \text{Mass of } B \times \text{acceleration of } B.$$

We give the name *force* to this product, and hence obtain the law that action and reaction are equal and opposite. On the basis of such definitions we can build up a structure of bodies in the conceptual world the motions of which, predictable under the descriptive laws formulated, will agree with the routine of our world of sense perceptions. We have in fact *explained* certain phenomena.

There is, of course, no logical reason why, in this description, we should stop short at the second derivative—acceleration—or go forward to it for that matter. We are concerned to find the simplest and most consistent explanation, and this procedure provides it. Indeed something of æsthetics may also influence our choice.

The atom, whatever its complexity, whether the concept remains sharp as that of a billiard ball or a miniature solar system, or whether its outlines disappear in a probability-smear, remains a *concept* outside the realm of perceptual happenings which it is the business of the concept to correlate. It may or may not emerge into the perceptual world ; unless and until it does discussion of its reality is beside the mark.

Planck, defining the causal condition in the statement that an event is causally conditioned if it can be predicted with certainty, goes on to remark that the possibility of making a correct prediction has not to be interpreted as anything more than a criterion for a causal correction, but not that the two mean one and the same thing. Day is not the cause of night, although we may be able to predict the advent of night in the daytime. Day is therefore a causally conditioned event.<sup>4</sup>

Taking the definition as it stands, we find that in the realm of quantitative physical events we cannot, purely as a matter of measurement, predict *accurately* in advance any one physical event—this, without introducing quantum considerations. Prof. Planck escapes from the indeterminist position by transferring the definition to a conceptual

<sup>4</sup> This definition should be carefully examined in the light of the arguments of Hume (*Enquiry concerning Human Understanding*, Section VII) and of Mill (*Logic*, Book III, Chap. V).

world in which exact measurements may be made and events correctly predicted. He assumes, in fact, in its broad outlines, the thesis of the *Grammar of Science*. He thus retains the principle of causality, as defined above, in the happenings of the conceptual world, remarking that the relation between events in the perceptual and conceptual worlds is subject to a slight inaccuracy.

The introduction of Heisenberg's uncertainty principle necessitates a corresponding process in dealing with perceptual problems from the point of view of quantum physics. A conceptual world of quantum physics is framed in which a strict determinism reigns. True, the world has not so many points of resemblance to the perceptual world as had the older schemes—billiard-ball and solar-system atoms have disappeared, and the wave-function, which does not refer to ordinary space, is not so easily interpreted in terms of the world of sense. But the philosophical problem of the transfer is the same.

Whatever the form of the picture the hard-pressed physicist of to-day remains on firm ground if he refuses to confuse the concept—the world-picture—with the percept; if, making this distinction, he studies the question of the reality underlying phenomena as philosopher rather than as physicist; if he is as ready to discard outworn models as ever Maxwell was.

There is no finality in these matters, and solutions of these difficulties are solutions for a day; but it is interesting and heartening to know that Planck, the initiator of the movement which has revolutionised physical thought, has, a generation later, pointed a way to a resolution of the fundamental doubts and difficulties which his genius has raised.

It must not be assumed that the discussion of uncertainty has passed beyond the region of fundamental criticism. In two recent papers in the *Philosophical Magazine*, Dr. Japolsky has developed a theory of elementary particles—electrons, protons, positrons, and so forth—which are considered as systems of Maxwellian electromagnetic waves. On this basis, using classical electrodynamics, he develops the usual quantum and relativity relations, including the de Broglie equation. The interaction of the particles follows the inverse square law (breaking down at small distances), and demands a mass-ratio between proton and electron which happens to be that deduced from experiment.

It is impossible to conclude a sketch of the trend of modern physics without touching upon the remarkable advances made in large-scale and applied physics; equally impossible is it to do more than mention a selection from such topics. The flotation process for the separation of minerals may be instanced as one, now of large-scale importance, which depends on a knowledge of physical quantities of very academic interest. In the practice of this process the powdered ore is churned in water which contains some substance capable of producing a stable froth. The mineral which it is desired to concentrate must cling to the surface and so remain in the froth, the gangue sinking to the bottom, and a reagent must be added whose action will ensure this. Obviously some very nice physical and physico-chemical problems are involved. In particular, a



knowledge of contact-angles—a rather neglected subject—is of great importance, and during the last year or two, much attention has been given to the measurement of contact-angles and to the application of the results to flotation processes. Indeed, a knowledge of surface-constants has many applications to industrial and to purely scientific problems, and it may not be out of place to draw attention to the curious shape of the curves showing the march of surface tension with temperature for certain crystalline liquids.

A most interesting application of classical atomic physics has recently been made in certain extensions of the theory of the Brownian movement. Measurements have been made of the Brownian movement of delicately suspended balances, movements due, of course, not to mass-motion of air or draughts but to irregular molecular bombardment, and a remarkably good value of Avogadro's number results from a determination of the amplitudes of such movements. Obviously if instruments become so delicate that their Brownian motion is appreciable, it becomes possible that Brownian motion may set a limit to the use of the instrument; this question has recently received consideration.

Electron diffraction has been applied with success to problems in technical physics. The very small penetration of even the swiftest electrons employed makes them peculiarly suitable for the study of surface structure, and the method has been used to attack such problems as the poisoning of oxide-coated filaments, and the study of lubrication.

Of the remarkable progress made in low-temperature research, we shall hear during the meeting of the Section. One other matter may be mentioned in passing—the development of precision methods in calorimetry which may make it possible to study accurately the temperature-variation of the specific heats of liquids (deuterium oxide, for example) available only in small quantities.

Of recent years our Association has concerned itself more and more with a study of the repercussions of the advancement of science on the fabric of our society. Never in the history of mankind have more powerful weapons for good and for evil been placed in the hands of the community as a direct result of the growth of scientific knowledge; and never has it been more necessary for the scientist to develop some awareness of the effects of his activities on the well-being of that community of which he himself is a responsible member.

We are most of us ready enough to discuss the 'Impact of Science on Society,' so long as we restrict ourselves to an enumeration of the benefits which science has bestowed upon mankind; and on occasion we may make a rather snobbish distinction between cultural and vocational values. But we have to remember actively that there are dysgenic applications of scientific knowledge, and if the scientist claims, as he rightly does, that place in the counsels of the nation which the importance of his work warrants, he must cease his worship of what Professor Hogben calls the 'Idol of Purity,' must be prepared to discuss all the social implications of his work and to educate himself, as well as his less fortunate brethren trained in the humanity schools, in a knowledge of these implications.



Our Association is peculiarly fitted to develop and discuss such knowledge ; in our own Section we have made a beginning but we have as yet touched on but few of these interactions. Our steps are naturally at first a little halting, but with increasing knowledge there will come, I trust, an increased power in elucidating those complex and difficult social problems which the astonishing developments of the last generation have forced on the civilised world.

## SECTION B.—CHEMISTRY.

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# THE TRAINING OF THE CHEMIST FOR THE SERVICE OF THE COMMUNITY

ADDRESS BY  
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PRESIDENT OF THE SECTION.

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My immediate predecessors in the presidency of this Section devoted their addresses to a review of recent progress in special fields of chemical knowledge, to the extension of which they themselves had materially contributed. On the present occasion I invite your attention to a topic of a different and a less technical character, namely, the chemist's place in the modern community and the kind of training necessary for an efficient discharge of his professional duties. One aspect of this topic was discussed at the Toronto meeting in 1924 by Sir Robert Robertson, who chose 'Chemistry and the State' as the subject of his address to Section B. The gradual growth in the official status of the chemist was traced from the point at which he was perforce summoned to assist in the defence of the State to his association in the post-war period with a variety of Government Departments and Government activities. This association has steadily extended in the intervening period, but, apart altogether from State activities, the science of chemistry and its applications are touching the life of the individual citizen more and more closely every day.

We have indeed moved far from the point of view expressed by Lavoisier's judge: 'La République n'a pas besoin de savants,' but even now there is often in influential quarters an inadequate grasp of the place and potentialities of the scientist. In the popular mind, and indeed by many who, to judge from their position, should be better informed, the chemist is still frequently associated merely with pharmacy or warfare, in neglect of the innumerable contacts of chemistry with the industry of the country, with the activities of the State, and with the health and comfort of its citizens. Let me begin by enlarging on these contacts and by emphasising the varied ways in which chemists are serving the community.

In relation first to those essential activities of any society which is intellectually alive—the pursuit of new learning and the cultivation of the spirit of inquiry—chemistry is in the forefront. For the promotion of natural knowledge and the increase of our understanding of the universe, the chemist has laboured with extraordinary success, both in his own fields and in those borderlands where chemistry marches with other sciences.

It is perhaps worth while glancing at one or two of the chief avenues in the region of chemical knowledge opened up by such fundamental research.

While our knowledge of atomic structure is to be credited mainly to the work of physicists, the chemist's technique has revealed the molecular architecture of the most complex natural products, and on the basis of this knowledge the same materials can be synthesised in the laboratory. One has only to think of the sugars, the alkaloids, the anthocyanins, to realise the astounding results which have been achieved in this field of investigation, while such elusive substances as the vitamins and the sex hormones are rapidly yielding their secrets to the strategy of the organic chemist.

Take again that region in the scale of size which lies between the molecule and the visible particle—the colloid region—the 'world of neglected dimensions' as it was once described. In this region, as the physical chemist has shown, the relatively great extent of surface is marked by quite special behaviour, and the labile systems encountered exhibit peculiar characteristics—characteristics which are highly significant for the understanding of physico-chemical changes in the living organism. Our knowledge of this field of surface chemistry is still extending rapidly.

Once more, think of the tracking down of the factors which affect the rate of chemical change and the elucidation of the mechanism of their operation: a little moisture, a speck of dust, a trace of acid, a roughened surface, a ray of light, a rise of temperature: any of these may have a notable influence on the rate of a reaction. The physical chemist has been remarkably successful in unravelling the rôle of these various factors and in interpreting their significance. It is in such a field as this—the field of kinetics and catalysis—that the progress of chemical science from the qualitative and descriptive way of treating phenomena to the rational and quantitative has been particularly marked.

These are only one or two of the directions in which the pioneering work of the chemist has opened the way to a fuller knowledge of Nature, especially in the more delicate aspects of her balance and her transformations. In the pursuit of natural knowledge for its own sake, the chemist has indeed travelled far and his exploration has yielded an abundant harvest of discovery. For the pioneer himself it is an adventure, and original research may provide thrilling experiences. All this, however, is far from the common ways of men, and the investigator in the field of pure chemistry moves in a region mostly inaccessible to ordinary folk, and he speaks an unintelligible language, as indeed is true of specialists in other sciences. The so-called 'jargon' of science, inevitable as it is to some extent, presents a real difficulty in the transmission of knowledge and ideas from the specialist to the average educated man, but it should not be forgotten that other specialists besides scientific workers have a jargon of their own: to wit, lawyers, financiers, and even sportsmen.

It has been maintained that the pursuit of learning for its own sake is a selfish occupation; that knowledge should be a means to life, not an end in itself, that knowledge is of value only in so far as it leads to action, directly or indirectly. With this view I have much sympathy,



but it has become abundantly clear, so far at least as knowledge and discovery in the realm of pure chemistry are concerned, that we must take a very long view indeed in assessing their practical value. Again and again in the history of the science observations and discoveries have been made, which at the time were of purely scientific interest but which later received important practical applications. The laboratory curiosities of a former generation, such as aluminium and tungsten, have become the industrial commonplaces of the present. The application of exact methods of measuring density revealed the presence of a new gas in the atmosphere—a discovery of purely scientific interest in the first place—which has led to a whole train of remarkable consequences, from a drastic revision of our ideas about the elements to the widespread development of illuminated signs. Just one hundred years ago, at the Bristol meeting of the Association in 1836, Edmund Davy announced the discovery of a 'new gaseous bicarburet of hydrogen,' now familiar as acetylene. Decades passed, however, before the novel gas acquired any practical significance, and indeed it was not until 1892, when a large-scale method for producing calcium carbide was discovered, that acetylene became of industrial importance. Since then its applications have gone ahead rapidly, and its uses in illumination, in welding, in metal-cutting, and in the synthetic production of organic chemicals are known to us all. In view of these lessons from the history of chemical science one hesitates to apply the epithet 'useless' to any specific observation or discovery, however 'academic.' Reflection indeed suggests that the really big changes in the material conditions of human life have generally had their origin in a search for knowledge on its own account.

There is, however, much more to be said on this matter of fundamental or academic research. A solution of the most practical of chemical problems on rational and scientific lines is possible only because of our accumulated knowledge of natural phenomena and natural laws. It is only against the background provided by the pure research of yesterday that the technical problems of to-day can be viewed in their proper setting and tackled with a reasonable prospect of success. I would submit, therefore, that work in pure science, remote as it generally is from the practical issues of the moment, is building up a real reserve of knowledge and technique on which future generations of practical workers will be able to draw.

Apart from the chemists who are engaged, mostly in our Universities and Colleges, but to some extent also in the larger research institutes, in the general task of extending the boundaries of knowledge, there are many more who are carrying on what may be called 'directed' research. Their work aims at the solution of some specific problem, concerned, it may be, with the improvement of an industrial process, the elimination of waste, the safeguarding of health, the utilisation of by-products, the synthesis of antidotes. More definitely, and by way of example, the object may be to discover a fast blue dye, to purify a water supply, to find a rustless steel, to produce petrol from coal, to isolate a vitamin, to make a non-inflammable film or a creaseless cotton fabric. The general public, however dubious about pure research, would probably admit that the satisfactory solution of any one of these problems would be of service to

the community ; but it must be emphasised once more that the chemist can do these things only by virtue of his inheritance of knowledge and technique. The attack on such problems, to have a reasonable chance of success, must be organised on the basis of what is already known and what has already been achieved ; nay, more, one has abundant ground for belief that the attack, so organised, is bound to succeed, even though it may be ' in the long run.'

In the last twenty years the amount of directed chemical research in this country has increased enormously. Industries of the most varied description have begun to realise the potential value of the trained chemist in solving their special problems and putting their manufacturing processes on a more rational basis. In this general movement the State, through the Department of Scientific and Industrial Research, has taken a prominent part by fostering Research Associations. The work of these organisations—such as those dealing with rubber ; with paint, colour and varnish ; with cotton or wool ; with non-ferrous metals ; with sugar confectionery—is in many cases largely chemical or physico-chemical in character. The Research Associations have not only shown how general problems affecting an industry as a whole can be solved by joint research efforts, but their existence and activities have induced a notable degree of ' research-mindedness ' in the individual associated firms. Financially, the work is based on co-operation between the State and industry, on the principle that the State helps those who help themselves.

The State itself has founded a number of organisations for the study of chemical problems of national importance, and has thus formally recognised the significance of directed research for the community. Six years ago one of my predecessors in this Chair, Sir Gilbert Morgan, gave an account of one of the most notable of these State experiments, namely, the establishing of the Chemical Research Laboratory at Teddington, and the investigation there of various important problems by a large staff of trained chemists. The work carried out at Teddington has included the study of synthetic resins and low-temperature tars and the exploration of chemical reactions occurring under high pressure, as well as research on metal corrosion, chemotherapy and water softeners.

Fuel and food are two notable cases in which State-aided investigation is being carried out, and problems connected on the one hand with pulverised and colloidal fuel or the low-temperature carbonisation of coal, and on the other with the storage of fruit or the preservation of fish and meat, are being intensively studied at appropriate centres. Reference might be made also to the work of the Building Research Station, where, amongst other matters, the factors determining the weathering qualities of stone are being studied. Other experts than chemists are naturally concerned in the investigation of these problems, but the chemical and physico-chemical aspects are frequently the predominating ones.

Again, the serious question of river pollution has been taken in hand with State help, and some years ago a chemical and biological survey of the river Tees was set on foot, the Tees being chosen for investigation because of the great variety of factory effluents discharged into it both in tidal and non-tidal reaches. Some of the newer industrial developments in



Britain are presenting important problems in this direction. It has been estimated, for example, that if the waste waters from all the beet sugar factories in this country were discharged into our streams they would cause as much pollution as untreated sewage from a population of four or five millions. The effluents from dairies and factories making milk products present a similar problem. Thanks, however, to research activity, largely at the instance of the Water Pollution Research Board, the disposal or purification of these and other trade effluents is being effectively achieved.

The question of river purification demands for satisfactory handling, as already indicated, the collaboration of other scientists with the chemist, and indeed the attack on many such problems, especially those affecting the health of the community, is likely to be successful only by the co-operation of teams of scientific workers from different fields. Smoke and fog, which not only present the scientist with interesting phenomena but constitute also a social and industrial problem of vital importance, concern the physicist, the physical chemist, the analyst, the fuel engineer and the meteorologist, and it is only when the knowledge and experience of these workers are pooled that there is any hope of interpreting the phenomena and solving the problem. Again, recent developments in cancer research make it clear that apart from the pathologist, who is mainly concerned, the chemist has a very definite contribution to make to our knowledge of this baffling disease. Some of the most fruitful scientific investigation, indeed, is co-operative in character.

Research, whether fundamental or directed, is by no means the only outlet for the chemist's knowledge and craftsmanship. The works control of chemical processes, the examination of factory products, the safeguarding of the purity of food, and the supervision of water supplies and sanitation, are examples of other activities of a more routine character in which large numbers of chemists are engaged. These are, so to speak, the general practitioners of the chemical profession, and their contribution to the smooth running of industry and to healthy living is far greater than most people suppose. I have myself been surprised, in a recent survey of the present occupations of my former students, by the extraordinary variety of the work in which chemically trained men may be engaged. This survey shows that photographic emulsions, beer, high-speed steel, printing ink, linoleum, dental cream, gramophone records, bank notes, and mineral waters, are a few of the materials with the production of which the chemist is concerned, either in the laboratory or the works. It is true to say that in the industry of the country the chemist is ubiquitous.

A few moments ago I spoke of the 'chemical profession,' and the phrase was used deliberately; it is really time that the British public and its leaders recognised the validity and the implications of the term. A profession is a vocation demanding high educational and technical qualifications, and it connotes also the body of those who by virtue of their qualifications are able to serve the needs and welfare of society in some particular field. On all these counts chemistry should have a place beside medicine, law, and engineering. That the public is so slow



in recognising this claim may be due to the fact that the chemical profession is not yet unified to the same extent as the others just mentioned ; but it is due also to a lack of realisation of the fundamental and widespread character of the service which the chemist renders to the community, and which I have emphasised in the foregoing part of this address.

A just estimate of the chemist's function is almost impossible for those who associate him chiefly with explosives and poison gas and regard him as a particularly devilish kind of scientist. Such a picture is hopelessly out of relation with the facts. It is, of course, true that chemists have produced dangerous and poisonous substances, but most of these were discovered originally in the general quest for knowledge, and many have legitimate and valuable applications ; their use for destructive purposes is a perversion. Phosgene, for example, one of the so-called poison gases, was discovered more than 100 years ago, and is an important material at the intermediate stage in the manufacture of certain dye-stuffs. Nitrates, which are the basis for the manufacture of most explosives, play a prominent rôle as fertilisers in agriculture, and explosives themselves are indispensable in mining operations.

The truth is that the employment for other than beneficial ends of the substances discovered by the chemist is due, not to his especial wickedness, but to the weakness and backwardness of the human spirit. Like other scientists, the chemist normally has a constructive point of view, and he cannot but deplore the fact that, as Sir Alfred Ewing said in his Presidential Address : ' The command of Nature has been put into man's hands before he knows how to command himself.' I think I speak for the vast majority of my fellow-chemists in saying that we dislike intensely the present world-wide prostitution of knowledge and skill to destructive ends. The sooner this is eliminated, and the less call there is for lethal and devastating materials, the greater will be our satisfaction.

There are, indeed, welcome signs that scientific workers are increasingly impatient at the extent to which their knowledge is made to serve inhuman ends. The possibilities before humanity have been fairly set out by a recent historian, H. A. L. Fisher : ' The developing miracle of science is at our disposal to use or to abuse, to make or to mar. With science we may lay civilisation in ruins, or enter into a period of plenty and well-being, the like of which has never been experienced by mankind.' To the clearing of this conflicting situation, the scientist has not always made the constructive contribution which he might have done : he has been content to adopt an objective and detached attitude, suggesting sometimes complete indifference to the wider human issues at stake. Unfortunately, if one may judge from a recent play by J. B. Priestley, this attitude is commonly regarded as typical of the scientist. Gridley, a ship engineer, addressing Fletherington, a research chemist, says ' You're all wrong. You're a nuisance. You're a menace.' *Fletherington* : ' I'm not, I'm simply a chemist, a scientist.' *Gridley* : ' I know, I know, and to-day you're trying to blow us up and to-morrow you'll be trying to dose us with poison gas. What do you want to go and make the foul stuff for ? Before you've finished you fellows'll do the lot of us in.' *Fletherington* : ' I'm very distressed to hear you talking like this, Mr. Gridley. I've never willingly

hurt anybody in my life. All I do is to research.' *Gridley*: 'Yes, and look at the result. Blowing us up, burning us alive, poisoning us. Just stop your damned research.'

This view of research, although it may be crude and ill-informed, nevertheless confronts the scientist with the question whether he is not assenting too readily to the misuse of his knowledge and skill. Impelled by patriotic motives, most scientists have put themselves freely at the disposal of the State in time of need, but many are hesitating to admit that patriotism must always override considerations of humanity. Whatever be our individual attitude in this matter, it is time for chemists and scientists in general to throw their weight into the scale against the tendencies which are dragging science and civilisation down and debasing our heritage of intellectual and spiritual values.

Reference has already been made to the increasing recognition by the State of the value of chemical research, but it is surprising how slowly those responsible for the machinery of government learn to appreciate the real scope of the chemist's work. A comparatively recent instance of the lack of clear thinking on this matter was furnished by the first draft of the formal rules dealing with the manufacture of pharmaceutical preparations containing poisons. Those allowed to control the manufacture were required to possess 'qualifications in chemistry,' and on this basis general medical practitioners were to be eligible equally with pharmacists and trained chemists. The idea that the general medical practitioner has qualifications in chemistry is ludicrous and the later drafts of the Poison Rules showed that this had been realised. The contention put forward in a Home Office Memorandum on these Rules that certain operations can be pharmaceutical but not chemical was equally ill-informed.

Inadequate realisation of what the chemist even now means for the community and failure to grasp his potentiality for development and progress may have unfortunate consequences in the commercial world. How often is it the case, although there are notable exceptions, that an industrial concern depending essentially on the successful operation of chemical or physico-chemical processes is controlled by a board of directors elected solely by virtue of their financial qualifications. Such men, as a rule, are without real appreciation of scientific method and scientific research, and, in the absence of a technical member who can speak with authority on these matters—a technical employee obviously cannot carry the same weight—such a board may make serious mistakes of omission or commission. No amount of financial manipulation, however skilful, can make up for the lack of enlightened scientific control.

If we chemists feel, as we certainly do, that the fundamental and widespread part which our science now plays in the community is not sufficiently realised, and if we consider that our profession should have greater influence in commercial, industrial, and national affairs, the remedy lies to some extent with ourselves, both individually and collectively. May I suggest that the phrase 'serving the community' not only describes what has already been extensively achieved by the chemist, but stands also for a high aim, such as has inspired, for example, the best traditions of the medical profession? The idea of service as a background



for life is not new—it is at least 1900 years old—but I believe it to be true to-day as always that the finest work in any sphere is linked with that ideal. The cynic will, of course, declare that the idea of 'service' in the present connection is both sentimental and irrelevant, and that concern for profits and pay need not be tempered with any less material considerations. Against this so-called realism I would urge that the spirit of narrow commercialism and professionalism, without vision of the potentialities of science for humanity, and without concern for the social issues involved, gives colour to the false view that science is anti-social.

Whatever may be our individual views on these questions, practical considerations suggest, and even demand, the formation of a corporate body to represent the common views and stand for the common interests of chemists as a whole. Much has been done already in this direction, but formal unification to the extent which prevails in the medical profession, for example, has not been achieved. The very diversity of the spheres of work with which chemistry is concerned means that the points of view and the interests of chemists vary widely: the outlook of the public analyst is not that of the research chemist or the man operating a chemical process on the factory scale. It is not surprising, therefore, that progress in the collaboration of chemists has been slow, and it is improbable that the chemical profession can ever become unified as closely and exclusively as the medical profession—even supposing it were desirable.

If for the moment we regard as 'trained chemists' all those who have taken an Honours Degree in Science with chemistry as the principal subject, or who have equivalent qualifications, their number in Great Britain is probably in the neighbourhood of 12,000. The majority of these are members of one or more of the three large chartered bodies concerned with chemistry—the Chemical Society, the Institute of Chemistry, and the Society of Chemical Industry. The Chemical Society, which is the oldest of the three and celebrates its centenary in 1941, has had for its chief objects the publication of new knowledge in pure chemistry and the building up of a comprehensive library—aims which have been achieved to a notable extent. The formation of this Society took place at a time when the professional and industrial aspects of chemical science were still in the background.

At a later date—over fifty years ago—the Institute of Chemistry was founded as a definitely professional organisation, designed to ensure the possession of adequate qualifications by those engaged in the practice of chemistry. The Institute, now the largest of the three chartered bodies, has had a considerable influence on the training of chemists, more especially for consulting and analytical practice, and membership of the organisation is, for certain kinds of chemical work, taken as a necessary and sufficient guarantee of professional competence. Unfortunately, however, there is not yet in existence a complete and authoritative register of trained chemists.

The rapid growth of interest in the applications of chemical science led to the formation in 1881 of the Society of Chemical Industry, which aims at the promotion of applied chemistry, by regular publication of relevant information and discussion of the latest developments. The members



are linked to one another in Local Sections, which are not confined to Great Britain, and by Subject Groups, which provide a common meeting ground for those interested in Chemical Engineering, Road and Building Materials, Plastics, and Food, respectively.

In addition to these three main bodies there are numerous smaller organisations concerned with chemistry in one way or another, such as the Biochemical Society, the British Association of Chemists, the Faraday Society, the Institute of Brewing, the Institution of Chemical Engineers, or the Society of Public Analysts, and the number of these is in itself a testimony to the variety of the chemist's activities.

Within the last two years a notable step has been taken towards the consolidation of the science and profession of chemistry by the formation of the Chemical Council, which is based on the three chartered organisations already mentioned, as well as on the Association of British Chemical Manufacturers, representing important industrial and commercial interests. The Chemical Council, set up in the first instance for a period of seven years, aims at securing a joint foundation for undertakings which have hitherto been the concern of separate organisations, and at enlisting the support of industry in this matter. The publication of new knowledge, either in the form of original communications or in the form of summaries of papers which have already appeared, is of the first importance in a science growing so rapidly as chemistry. For every chemist, whatever be his particular field of work, some acquaintance with new views, new discoveries, new applications, is essential, and the publication of new knowledge in the appropriate form is really a concern of the whole profession. The successful prosecution of this enterprise is a vital matter also for the industries which depend for their smooth running and their progressive development on the application of chemical knowledge and the furtherance of chemical research.

If the newly established Chemical Council can unite the chemical profession and the chemical industry in support of publications and other objects of similarly wide appeal, such as a central library, it will have achieved a notable advance. Its formation is the earnest of further moves in the direction of consolidation and unification of the chemical profession, such as the acquisition of adequate central premises and the establishment of a complete register of trained chemists.

This leads me to consider the kind of preparation which is necessary in order that a man shall be qualified for such registration. The training of chemists, as of other professional men, has for its necessary basis a broad general education for character, culture and citizenship—in the achievement of which the teaching of science can play a distinctive part. Regard for accuracy in observation and in statement, understanding of logical reasoning, interest and delight in the natural world, appreciation of scientific discovery and its meaning for human life—all these are, in some measure at least, within the grasp of the child under the guidance of a live teacher. In this connection it is unfortunate that the elements of biology are taught in comparatively so few schools. It is admittedly easier to arrange for elementary instruction in the physical sciences than in biology, but, as things are at present, boys, especially, see as a rule

only one side of science—they find themselves in a physics-chemistry groove, and this groove may become a rut. My own experience of students from secondary schools (including public schools) proceeding to a university honours degree in chemistry shows that not more than 1 in 12 has had any previous contact with biological science. Apart from the special and intimate relationships between chemistry and vital phenomena, such a state of affairs is regrettable on general and cultural grounds.

After the School Certificate stage our future chemist appropriately begins some specialisation in science, either during his last years at school or during his first year at University or College. The special science teaching in secondary schools now reaches in many cases a high level of excellence, but owing to various causes, notably scholarship requirements, the extent of specialisation in physics, chemistry and mathematics during these last two years has become excessive. Not only does this involve a reduction of time and energy for desirable cultural subjects, such as history and English language and literature, but it may mean that the student comes to the University without a mastery of the tools which he will later need in his specialist work. In the case of the chemist this applies especially to the German language, and at the moment we have the absurd position that many University Departments of Chemistry are finding it necessary to teach their students German, while the schools on the other hand are busy giving specialist instruction of University standard.

The student who has passed the Intermediate Science stage and who has decided to become a chemist has two or three years' training in front of him before he enters for his final examinations. In what way can the most profitable use be made of this time? The attempt to answer this question in detail would be out of place here, but there are a few general considerations which should not be forgotten in connection with this stage in the training of the chemist. In the earlier portion of this address emphasis was laid on the extreme diversity of the tasks which the chemist may be called upon to undertake in his professional career, and clearly, therefore, it is the basic principles of the science that should mainly occupy his attention during his University curriculum. His training must be on broad fundamental lines, and any attempt to plan a University undergraduate course with a view to preparation for some specific chemical occupation, such as paper-making or dyestuff manufacture, is entirely misconceived.

On the other hand, the breadth of the chemist's undergraduate training may be sacrificed to intensive and perhaps excessive study of some academic aspect of the subject. The criticism is made to-day—and in my view it has some justification—that our graduates in chemistry are weak in their grasp of the fundamentals of the science. It is said that they can talk at length about nuclear spins, valency angles, electron sinks, energy levels and so on, but are astonishingly uncertain about more elementary and practical matters. The explanation is not far to seek. Discoveries in atomic physics, radioactivity and other fields have revolutionised the outlook; our basic ideas about matter and energy have been radically altered and extended; chemical properties and reactions have been re-interpreted in terms of the electron and the quantum. The interest and significance of these developments are obvious, and all sound chemical



education must incorporate the new knowledge and the new ideas. It does appear, however, that the attempt to present these in all their detail to the undergraduate chemist has involved correspondingly sketchy treatment of less novel, but still fundamental, elements of his training. Further, in the chemical and physico-chemical fields opened up by these new developments there has been a luxuriant growth of theory and speculation, often ephemeral in character and rendered impressive only by a buttressing of mathematics. A good deal of this enters into the university teaching of chemistry, but much of it has merely an examination value and contributes nothing to the permanent equipment of the average student—the man whose interests must be kept steadily in view.

The present prominence of this 'armchair' chemistry suggests that there is another consideration which we academic people are apt to forget. So far at least as the service of the community is concerned chemistry is a practical science and the most of the students under training are to be practising chemists. Academic purists may protest that chemistry is a philosophical discipline, not a bread and butter affair, and that anything savouring of vocational training is foreign to the function of a University. It is, however, to the national interest that knowledge and action should be co-ordinated and that our Universities should not be divorced from practical affairs. The existence of our Faculties of Medicine and Engineering shows that in other important fields of national service the Universities have accepted the burden of putting vocational training on a broad foundation of scientific knowledge. In the training of the chemist, then, knowledge of fundamental principles must be coupled with practical competence, craftsmanship and technique, and here I would stress the importance of accurate quantitative analysis as one essential element in the education of the chemical student. Apart from its value as enforcing the essentially exact nature of chemical reactions, experience shows that the successful solution of organic or physico-chemical problems depends in a great many instances on some accurate analytical operation. Laboratory practice and craftsmanship in general, the value of which is discounted by certain schools of physicists to-day, is indeed an indispensable feature of the training of the chemist.

Along with the laboratory I should like to emphasise the importance of the library, and here I refer, not to general university facilities, but to a departmental library, small it may be but workmanlike, and run as a real element in the chemist's training. With their eye on examinations many students regard lectures and laboratories as providing the sum total of all wisdom, and yet it is essential that they should have direct access to the original sources of information and learn how to use them. This is best done in a departmental library, accessible and up to date, but success will be achieved only when responsible members of the staff take a real interest in this side of the student's training, and make the library a live affair.

No single science is self-contained and no man can be a chemist without some knowledge and experience of cognate fields. Hence it is appropriate that the undergraduate student of chemistry should study physics or biology, for example, as a subsidiary subject, and this is generally provided for in the courses which lead to an Honours Degree in Chemistry as the



main subject. Where the interval between the Intermediate and the Final Honours Examinations is only two years, time-table considerations unfortunately may forbid the study of more than one subsidiary subject. There is much to be said for a minimum period of three years, which would not only relieve the congestion of a two years' specialist course in chemistry but would enable the student to acquire a broader outlook on related fields of knowledge. In some Universities where the three-year interval between Intermediate and Final Honours is in force, the chemistry student takes a general degree—or its equivalent—in three subjects before proceeding to the Final Honours year, and this arrangement has much to commend it.

As to the subsidiary subject or subjects themselves, there should be much elasticity, and the student's own aptitudes and interests should be the determining consideration. Thus while all chemists should have a working knowledge of mathematics up to the calculus, it would be a mistake to make more advanced work in this field obligatory as a subsidiary subject, irrespective of the student's individual capacities and interests. On the other hand, the chemistry student who has a real flair for mathematics—in my experience he is a rare bird—should have every encouragement, both before and after graduation, to cultivate his special talent. Such encouragement is specially effective if it is backed by members of the mathematics staff with some appreciation of the chemist's outlook and requirements.

The Honours course in pure chemistry which is current in our Universities is itself very specialised and, in my judgment, lacks flexibility. Many chemical undergraduates are frankly more interested in the practical application of the broad principles of chemistry than in the refinements and subtleties which figure largely in our honours courses of lectures. Such highly specialised instruction may be appropriate for those who are to spend their lives working in the field of pure chemistry, but it has limited value for those who are less interested in knowledge for its own sake than in its application for practical ends. In physics the necessity of providing for these two types of workers has long been recognised and our Universities welcome students of electrical engineering as well as students of pure physics. In view of these considerations serious attention should be devoted to Chemical Engineering as a degree subject. Experiments in this direction have already been made in one or two places, and the question has been raised afresh by the recent proposal of the Imperial College that an undergraduate course in Chemical Engineering should be instituted, covering three years after the Intermediate stage. It is essential that any course such as that proposed should be based on the fundamental principles of physics and chemistry, with the requisite mathematics, and should cover their general application in the field where the chemist and the engineer have common interests and common problems—a field which is very largely that of physical chemistry.

The oft-repeated criticism that the man trained on the lines proposed would be neither a chemist nor an engineer is merely formal and unconvincing; the water-tight separation of the two professions is entirely artificial, for in chemical industrial practice there are many who are

primarily chemists but who have to handle large-scale operations on engineering lines. Why should this fact not be faced and the appropriate adjustments made in our University courses of training? It is true that at the present time some men trained in pure chemistry take a post-graduate course in chemical engineering, but this is a piecemeal way of acquiring the relevant knowledge and technique, and the welding of the two disciplines in a balanced curriculum should produce much better results. If the Universities will take this matter in hand, the training of the chemical engineer will be moulded on lines consistent with that study of fundamental knowledge which it is the function of the Universities to promote.

As in medicine, the man who is at the end of a chemical undergraduate training is only at the beginning of that experience of life and practice which will make him a mature member of his profession. In some cases, depending on aptitude and temperament, it is best that this further experience should be begun outside the University and that the new chemical graduate should at once exchange the comparative calm of academic lecture-rooms and laboratories for the rough and tumble of industrial conditions. These are the cases in which sufficient technical basis is provided in the undergraduate course for a career which will lie more in the field of production management and administration than in that of scientific control and development.

On the other hand, in the majority of cases, the chemist who has just completed his first degree curriculum is well advised to spend one or two post-graduate years at the University, either in research or advanced study, securing in this way the opportunity for more intensive and deliberate work in some special field. While I do not consider that research should invariably be the occupation of the post-graduate chemist, it is essential that all those with distinct originality and with ambition to extend the boundaries of knowledge should have the chance of learning the art of the pioneer and of experiencing the thrill of discovery. It is from the ranks of such post-graduate workers that the Davys and the Faradays, the Ramsays and the Perkins of the future must be recruited, and accordingly joint research by staff and students should be a prominent feature of all chemical departments in our Universities and Colleges. If the investigations proceeding in any one department are of a varied character, so much the better, for where a single field is being explored on established lines, an individual worker may be little more than a cog in a wheel, with only slight benefit to himself.

In the case of those who have no apparent talent or inclination for research, the post-graduate period is more profitably spent in acquiring special knowledge of some particular field. With a thorough undergraduate training in chemistry as a background, intensive work in, say, biochemistry, agricultural chemistry, metallurgy, or the chemistry of food and drugs, provides technical qualifications of a valuable order. At the same time, it must not be forgotten that, however good the post-graduate training in research or advanced study may have been, the chemist will be faced with new problems and new situations when he enters the works laboratory or the factory. This marks the opening of a fresh

chapter in his training, and although he may already have acquired a sound knowledge of specific principles and scientific method, he is but a beginner in other respects, and the new situation may make a heavy call on his adaptability and common sense. Real achievement at this stage depends largely on character and personality, the possession of which is outside the guarantee of University degrees. For the chemist who has not only intellectual ability and technical competence, but also qualities of leadership and judgment, there is abundant opportunity, and our industries could profitably absorb many more men of this calibre.

Since the war there has been a notable increase in the number of openings for trained chemists and there is a steadily growing demand for such men. It is imperative, however, that the standard of training shall be maintained at a high level with the objects of scientific progress and professional competence always in view. There is no doubt that, given adequate financial and commercial co-operation, chemists trained in our Universities and Technical Schools will be able to meet all demands on their skill and knowledge and to make their full contribution to the industrial and social needs of the community.

Consideration, indeed, of the scientific and industrial developments of the last few decades warrants the view that all technical requirements of the community in goods and services can be met sooner or later. While, however, knowledge and skill increase, wisdom lingers, and it looks as if the real problem at the moment before the nation—before all civilised nations—is not any difficulty in technical service or technical production, but the wise use and distribution of the natural and synthetic products which science has put at our disposal in such abundant measure.



## SECTION C.—GEOLOGY.

# PALÆONTOLOGY AND HUMANITY

ADDRESS BY

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FEW branches of scientific research are less familiar to the general public than Palæontology. Restorations of extinct animals, glowering in museums or quivering on the screen, do little to provide an understanding of the subject; they savour unduly of the temptation to start reading a novel at the wrong end. It is scarcely an exaggeration to say that to most people, and not to the illiterate alone, the activities of palæontologists are unknown or mysterious. In many quarters a fossil-hunter is still looked upon as perhaps amiable, and probably harmless; while the small economic value of his treasures is a clear index to the abnormality of his mind. Most of us who work in the field still experience the difficulty of convincing casual observers that the specimens we collect and cherish are objects worthy of the attention of grown men who are also sane.

It is not my intention to comment here on a system of education that omits to give to its victims an intellectual appreciation of the world in which they live. Any such diatribe would be dismissed, like all criticisms of established custom, as the product of a biased mind. But I hope that the facts and logical deductions that I am about to put before you, from the privileged position in which you have placed me, may reach beyond the walls of this room (where we are all of the true faith) and convince sceptics that Palæontology has a message of vital importance to mankind. With this intent I propose to pass over the obvious geological applications of the science, concentrating attention upon its biological aspect.

Palæontology is, by name and nature, an historical study. Its aim is to decipher the records of past life, and to translate the story into human language. Without some knowledge of this sort, true appreciation of life in the present is impossible. One of the main factors in human progress has been an ability to learn from the experience of past generations. That mankind is often lamentably 'slow in the uptake' in this respect only emphasises the importance of his faculty; for when discredited experiments are repeated progress is postponed.

The old-fashioned type of biologist who ignored or rejected fossil evidence was in the position of a man who, suffering from loss of memory, might try to understand the present international situation with no other guides than this morning's papers. This forlorn type is now virtually

extinct ; but we still have hosts of earnest workers, battling with problems directly concerned with mankind, who either know nothing of man's place in nature or even deny that he is subject to natural laws. In such cases ignorance and prejudice are far more dangerous than when they inspired opposition to Galileo ; to living beings the laws of life are more directly important than those of planetary motion.

It is difficult to recapture the sense of amazement that must have assailed the minds of those who first observed and pondered over fossils. The ideas aroused by the 'figured stones' must have seemed grotesque and incredible even when they fell short of profanity. Many and various hypotheses were devised to explain away facts whose obvious interpretation did violence to accepted tradition. During the seventeenth century, mongrel mixtures of imperfect observation and misread Scripture appeared in polemic succession as 'Theories of the Earth.' These treatises can never become out of date. Much as they resemble guides to Wonderland written by the White Knight, they are good illustrations of the perennial danger of logic based on incomplete premisses.

Fossils were ascribed to astrological conjunctions, meteoric showers, thunderbolts, and even to the machinations of the Arch-fiend. Belief in the celestial, or at least cosmic, origin of fossils was very general ; perhaps it was fostered by the abundance of 'Shepherds' Crowns' on the ploughed fields. The five-rayed pattern of these casts of sea-urchins, no less than the stellate structure of nodules of pyrites, linked all 'extraneous fossils' with the stars. Sounder reasoning, in the light of the knowledge then available, prompted a belief (championed strongly by Nicholas Lang) in some fertilising essence that generated fossils in rocks as it did jelly-fish in sea-water.

At last, as evidence accumulated, the inevitable and (to us) obvious interpretation of fossils became accepted by all who studied them ; although then, as now, the opinionated felt qualified to deny truths of which they were ignorant. The situation was admirably summed up in 1732 by J. P. Breynius in his treatise on the reputed petrified melons of Mount Carmel. He showed convincingly that these objects were crystal-filled geodes ; but in so doing he was anxious to avoid casting doubt on the organic nature of true fossils. He expressed the opinion that, after the revelations made by Columna, Steno and Scilla, 'he who would doubt the truth of the assertion [that the *Glossopetræ* of Malta were true sharks' teeth] must assuredly have a fungus for a brain.'

Real progress in the study of fossils had to wait until a change of fashion allowed persons of intelligence and refinement to leave the chaste shelter of libraries and cabinets and to expose themselves to the rigours of the open country. Hitherto savants had been content (for the most part) to speculate and debate over specimens brought to them by illiterate yokels ; and they often wove into their theories the fantastic stories with which the discoveries had been embellished. The greater part of two centuries

had been wasted in 'empty speculation' (as Scilla described the efforts of his contemporaries) before philosophers learned the value of physical labour, with its accompaniment of honest dirt, as a clarifier of the mind.

And so we come to the heroic period of the late eighteenth and early nineteenth centuries, when students of Geognosy began to collect fossils for themselves. Immediately two sciences sprang to birth. Geology, as we understand it to-day, found in fossils the link that gave continuity to a mass of disconnected observations; and Palæontology took its place as the science of the succession of life. The discovery that 'Strata [can be] identified by Organised Fossils' must surely rank among the greatest episodes in the history of human thought; for to it we can trace directly our conception of geological time and our realisation of the fact of evolution. Throughout the past century both of these revelations were hotly contested; for since the days of Elijah truth has always been at variance with orthodoxy; but a recognition of the orderly succession of events in the history of the world, inorganic and organic alike, gradually dawned on all but the most benighted minds. To-day we can, with such concessions to modern delicacy as may be appropriate, apply the dictum of Breynius to those who doubt, and especially to those who deny, the established facts of history.

Since I propose to exploit to the full a Presidential licence for generalisation, it becomes necessary to remind myself and you of the value of the evidence on which the generalisations are based. The depth and range of the conceptions of which Palæontology treats, and the importance of the conclusions to which they lead, are such that a critical audit is periodically imperative. Evolution is a principle that interests and influences every man, whether he likes it or not; and for that reason it is in constant danger of becoming discredited by wild generalisations. Every teacher knows the absorbent nature of the student-mind which willingly accepts as doctrine suggestions that were not meant to be the commandments even of men. We spend our lives in disproving the axioms of our youth. I is, then, most important that palæontologists, who alone can speak with authority on the course of organic evolution, should be careful of what they say. Heaven forbid that they should ever cease to theorise and speculate; but they will do so better if they remember occasionally the nature of the foundation on which the apex of their logical pyramid rests.

In any kind of historical research there must always be a vast quantity of undiscovered, and indeed unrecorded, facts. Many of these lost data are doubtless best served by oblivion (*vide* the daily Press); but, in the intricate ramification of affairs, apparently trivial incidents may prove critically important. Nevertheless, a few average samples of news, selected on a definite principle, will give a fairer picture of historical truth than a welter of flashy details that are 'news' because they are abnormal.

The imperfection of the geological record is patent and inevitable, for all stratigraphical history is written in palimpsest. The palæontological record is inseparably involved in the geological; so that disjointed scraps of evidence are all that we can expect. Even when no obvious mutilation,



such as angular unconformity, defaces the record, there is no reason to assume that the story is consecutive. Just as a net has been described as a set of holes held together with string, so a series of strata must often represent a succession of non-sequences separated by films of sediment.

In addition to the accidents of destruction inherent in the nature of the geological record, there are many gaps due to biological factors. Not only do organisms devoid of hard parts perish, usually without trace, but many of all kinds are destroyed in providing food for their successors. The biological palimpsest immortalised on Ilkka Moor is almost universal.

Apart from accidental occurrences that are too rare to provide more than surprise, fossils consist of the 'hard parts' only of the creatures they represent. While in some cases these structures may consist of toughened organic material (as, for example, wood or chitin), they are usually built of mineral matter secreted or excreted by the organism. Such shells and skeletons are valuable to their owners for protection or support; but at best they have a secondary significance in that they are the least 'alive' parts. Skeletons are closely associated, and intergrown, with living tissues; but shells have no closer connection with their builders than any other kind of homespun garment.

There is thus a serious limitation, in both quantity and quality, of the amount of direct evidence available for the appraisal of the characters of extinct organisms. Palæontologists share with anatomists the disadvantage of studying life after it has gone; but they are further penalised by having access only to those parts of the living mechanism that were never more than half alive. When we superpose on this Ossa of imperfections the Pelion of the human factor (in the matter of collection, preservation and interpretation of specimens), there does not seem much left.

As regards the quantity of evidence available, its limitation is our salvation. However short it may fall of the total amount possible, it is enormous. In many respects we understand the principle by which it has been selected, so that we are in a position to estimate its proportionate value. Moreover, such material as is preserved for us has been kept in its right chronological order. The fact of succession gives ample compensation for shortcomings in other ways.

The quality of fossil evidence is, in effect, far higher than might be expected. Although fossils represent but portions of organisms, they are not therein unrepresentative. In the laboratory of research in Scotland Yard, a mere finger-print is known as a sure criterion for identification. A finger-print suffices not only to show some inborn and peculiar character of its maker, but often includes features that reveal something of his habits and experiences. Most fossils, certainly those on which conclusions of importance are based, are far more than finger-prints. In spite of a need for caution owing to the vagaries of convergent development, a single character is generally enough to serve as a basis of identification of an organism. The plumage of birds, the wing-scales of Lepidoptera, or the pollen-grains of plants are even better indices of the several species of a group than many more intimate anatomical features. Indeed, experience shows that 'vital' structures are very uniform throughout families or even

orders of organisms ; the differences that distinguish genera and species are usually trivial and superficial. Hence the restrictions laid on palæontologists, though regrettable, are in no sense crippling.

Skeletons and shells are particularly informative as to the relation of an organism to its environment, and thus of its habits of life. In this matter a double check is available. Not only can we study the connection between the skeletal and shelly structures of living types and their environment, and so infer the significance of similar characters in extinct forms ; but by a study of the lithology of the sediments in which fossils are found we can deduce the physiographical conditions prevalent at the time of their burial. There is, indeed, little to choose between the opportunities of neontologists and palæontologists for studying the relation between structure and environment, and, with the shifting scene of geological history, palæontologists have a unique opportunity to observe the reaction of structures to environmental change. It is here that Palæontology can make a contribution to biological philosophy no less important than its addition of extinct types to the storehouse of biological facts.

A short digression into the subject of taxonomy will be useful at this point. In matters of classification Palæontology has proved a disturbing agent. The so-called 'natural' classifications of the past, based on conveniently fixed characters, were delightfully simple as well as useful ; but they are out of date and even misleading to-day. Whatever other principles may or may not have been proved by Palæontology, it has been shown beyond cavil that the characters of organisms do not remain fixed for long. Indeed, it is impossible to hold any longer a belief that they are fixed at all. The new problem thus confronting systematists can be expressed by analogy. The old classification aimed to produce a catalogue or dictionary in which each item or word was defined as an entity ; the new classification has to devise an etymological concordance, where the history and context of each word is more important than its ephemeral usage. Modern systematists deserve every sympathy as, with scissors and paste, they try to re-edit into a new design the myriad items of their catalogues.

Considerable confusion has arisen through the unavoidable differences in the bases of classification used in Palæontology and Neontology. A neontologist can, and should, invoke all the morphological, embryological, ecological, physiological and psychological qualities of an organism as criteria in taxonomy ; a palæontologist can observe only a fraction of the first three of these qualities. But he can study the chronological order of succession by way of compensation for the rest. There is actually little to choose in the quantity of evidence of taxonomic value available in the two lines of inquiry ; but the emphasis falls differently. In practice a palæontologist recognises that the chronological factor outweighs all others in significance ; but he envies and borrows from the wide range of information available in Neontology. A neontologist is rarely content to-day to restrict his inquiries to the ephemeral matters that are his rightful scope ; he steals the palæontological 'thunder' of succession to



give verisimilitude to an 'otherwise bald and unconvincing narrative.' The distinction between Neontology and Palæontology is fading; and with its passing all other taxonomic boundaries grow dim.

There is, however, a real difference in the two attitudes towards classification, and a difficulty in correlating them. This is due to the vastly greater series of characters possessed by a living creature compared with the small number that persist after its death. Zoologists and botanists can study ontology and ontogeny, whereas the student of fossils must be content with partial morphology and morphogeny. Fortunately, in the nature of things, the various organs of an organism are so intimately related that any one of them may give presumptive indications of the rest; but this is not invariably true, and scarcely ever convincing. There is room between the valves of a Pelecypod shell for any or all of the anatomical peculiarities on which Pelecypods are classified, and very little likelihood that the shell will show which of the many possibilities it actually enclosed. This difficulty applies in the case of all shell-bearing organisms; it is less acute where skeletal structures are concerned. We do not know how many gills the Ammonites had, and so their true position among the Cephalopoda is unproved; but we do know the disposition of the water-vessels in fossil Echinoderms, and the course of blood-vessels and cranial nerves in extinct Vertebrates.

Most of the characters regarded as of specific importance in modern types are superficial. They are real enough, but only skin-deep. The colour of feathers, the hairiness of foliage, or the proportions and ornament of shells, may serve to differentiate between forms that, though otherwise structurally similar, are completely different in habits, distribution and fertility. A palæontologist can hope, therefore, to recognise in fossil shells specific characters comparable with those so regarded by neontologists.

Generic characters, in so far as they can be defined, involve structural differences of a more deep-seated nature. Most of them are revealed only by dissection, and most are found among the softer tissues. Such characters may often have a visible influence on skeletal structures, but they rarely affect shells. In Echinoderms, Vertebrates and Plants it is possible for a palæontologist to distinguish sections that are virtually equivalent to the neontologists' genera, and to follow consistently up into higher groupings.

We find, therefore, that a palæoconchologist can classify shells specifically, and usually no further; while his colleague who deals with skeletal structures can recognise ordinal and generic, but no smaller, characters. In effect, a fossil shell is naturally recognised as a species, and arbitrarily placed in a genus; while a fossil skeleton may be naturally classed into a genus, and cannot properly be described specifically. That it is usually so described upsets the balance of classification; but since taxonomy is at best an artificial scheme, the trouble is not serious so long as it is realised.

Whatever may be the requirements of his stratigraphical colleagues, a biological palæontologist is less concerned with genera and species than with series and trends. His interest lies in the progressive modification



of certain accessible structures; there he can find facts, whereas his excursions into phylogeny must always have some speculative element.

This limitation is by no means so serious as it may appear. Any organism consists of a mass of interrelated characters, each of which should rightly contribute to the harmonious working of the whole. It is obvious that many of the characters of an individual suffer change during its lifetime, and that these changes are not attained at a uniform rate. Indeed, individual life can be likened to a chord which is persistently modulated by alteration in value of its component notes, until the time comes when one or more of the notes is so altered that it produces discord, a sure foreboding of disease and death. As a consequence, a careful watch on the changes that affect a few characters will suffice to show both the nature of such changes and their influence on the well-being of the organism concerned.

Palæontologists thus study the history of organic structures rather than that of organisms, thereby indirectly watching the fate of the owners of those structures. In large measure the application of generic and specific names (an arbitrary habit even in Neontology) is tentative. It gives convenient, but often false, means of expressing morphological qualities. Such familiar 'genera' as *Gryphæa* and *Exogyra* can be shown to represent stages in the morphogeny of oyster-shells belonging to manifestly different lineages, so that they are not genera in any strict sense. They correspond to such epithets as 'crony' or 'gaffer' as applied to stages in human development.

There is a wide range of variation in the durability of fossil types in geological time. This variability affects all grades in classification except perhaps the highest, and may be assumed, granted a sufficiently long perspective, to affect all. Some classes, such as the Spire-bearing Brachiopoda, lasted no longer than two eras, while others, such as the Atreme Brachiopoda, have endured throughout the known record. The families into which such classes are divided often show proportionate durability; the spire-bearing Atrypidæ, for instance, being limited to about two periods, while the atrematous Lingulidæ have persisted from Ordovician times to the present day. Similarly, the genera and species of such families follow, in general, the fashion of the groups to which they belong. If we consider a stratigraphical hemera as analogous with a year, and a genus as an individual unit, it would be fair to recognise some genera as annuals, some as biennials, and others as perennials of varied longevity. It is worth noting that a precisely comparable variability of expectation of life applies in the case of individuals; so that, accidents apart, an oak tree will live longer than a sycamore and a man than a mouse.

Within the framework of a class there is actually much variability of time-range. In the contrasted cases of the Brachiopoda cited above, the family Spiriferidæ persisted through four geological periods, whereas several families of atrematous Brachiopoda seem to have been limited to the Cambrian period. Again, among the Echinoidea, the small regular sea-urchin *Hemipedita* appeared at the outset of the Jurassic period,

and still survives ; whereas *Diademopsis*, a type so similar as to be almost the despair of systematists, appeared at the same time and failed to outlast the Jurassic period.

There is also a wide range of difference in the geographical distribution of genera and species, seemingly independent of the time-range. While it is, of course, natural that planktonic forms, such as some of the Graptolites, should be drifted far and wide by ocean currents, it must be realised that most marine organisms pass through a planktonic stage in development. Not all of them take advantage of this opportunity for wide dispersion. In view of the uncertainty as to the truly specific identity of fossils that are apparently alike, and of the incidence of orthogenetic and convergent trends in morphogeny, the problems raised by the study of palæogeographical distribution are too hypothetical to be considered here.

These diversities of quality, in duration and dispersion, of fossil types in all grades of classification are strikingly reminiscent of the differences of longevity and migration that may occur in different individuals of a single species, or even of a single generation born of the same parents. Whatever may be the explanation (and we know the causes of such diversity to be infinitely complex in the case of members of our own species), the tendency towards, or capacity for, the differences seems to exist as a general principle throughout living matter. Palæontology merely shows here that a quality of life with which all of us are personally familiar applies equally in the larger histories in which individuals or generations are but transient incidents.

In the perspective given by geological time, we may hope to detect some of the outstanding characters that accompany, and perchance influence, the success or failure of a group of organisms. We lose sight of the innumerable trivial accidents that determine the fate of an individual, so that more fundamental tendencies become clearer. In this particular instance we can observe the characters that history has proved to be associated with longevity or its reverse.

Without enumerating actual cases (which would be tedious for those who know and still more so for those who do not) we can make at least one generalisation that seems to be true. Simplicity of structure, so long as it is combined with reasonable efficiency, is associated with palæontological longevity ; while complexity of structure, however efficient, implies relatively brief duration. We need not at this stage look for a reason for the existence of such qualities, but it is patent that they exist. The reason for their effect, however, is so manifest that it could be adumbrated even if proof were lacking. Any organism must of necessity be in tune with its environment if it is to survive. Elaborate structures can fit only a special type of environment, whereas simple structures have a wider scope of possible harmonies ; just as a chord of many notes is less easily harmonised with another than a single note. In geological time, environmental changes are inevitable, so that simple structures will have a better chance of survival than complex ones. The platitudinous nature of this statement is well shown in everyday experience, for the ignorance of a thoroughgoing specialist of any but his peculiar brand of knowledge is notorious.



Study of the 'survival-value' of various types in groups whose palæontological history is adequately known reveals many points of interest. Every group includes some types that are relatively persistent and others that are relatively ephemeral. For example, among the sea-urchins, *Cidaris* has persisted with no important modification from the Triassic period to the present day; the family of the Cidaridæ ranges back to the Carboniferous period. *Echinocystis*, a sea-urchin that appeared long before any of the Cidaridæ, was limited in range to the Upper Silurian. *Heterosalenia*, appearing first in the Upper Jurassic, disappeared in the Upper Cretaceous. Now *Echinocystis* and *Heterosalenia* were both much more elaborate in structure than *Cidaris*, so that their short ranges illustrate the generalisation made above. But *Bothriocidaris*, an early Echinoid far simpler in structure than *Cidaris*, appeared and became extinct within the Ordovician period. A closely parallel series of cases could be cited among Brachiopoda or Mollusca. In these groups the persistent genera *Lingula*, *Nucula* and *Patella* were neither the earliest to appear nor the simplest in structure. They represent, however, like *Cidaris*, the simplest types capable of living with a fair measure of efficiency in the circumstances appropriate to their kind. Such types never attain the temporary importance often reached by highly specialised types; they remain comparatively obscure members of the fauna: but they remain. No imagination is needed to see in a limpet the modern representative of a type that was ancient before the first Vertebrate appeared. A trace of poetic insight would show that its humility has been its salvation.

The harmony that exists between the structures of organisms and their environment would be incredible were it not commonplace. But the explanation of that harmony is not yet available, although from the days of teleology to the present it has been the ultimate aim of most biological research. Do organisms endowed with certain structures deliberately select suitable environments (as a Red-underwing moth chooses an elm-bole as a resting-place), or does the environment impress on, or extract from, the organism appropriate reactions (as the grime of a city seems to induce melanism)? Even to-day the only safe reply to this question is to repeat another about a hen and an egg.

Nevertheless, in one aspect of the question there is definite evidence. On individual organisms environment can at least exert the power of a final veto. Environment the executioner is so potent in individual life that it may, indeed it must, accelerate the extinction of any series of organisms whose structures fail to conform to its requirements. A constant environment is a sure means of maintaining constancy in the characters of successive generations; any deviation from the permitted pattern cannot fail to prove less perfectly attuned than the orthodox plan. In geological time, however, environment is sure to change, so that a group of organisms will inevitably drop behind the times unless it can adjust its characters or its distribution to the shifting demands of its surroundings.

Ample evidence of the soundness of this argument can be found in Palæontology. Although groups of organisms may become extinct at



any time in the geological cycle, there is a marked increase in their mortality coincident with the major physiographical paroxysms. Indeed, at the Caledonian, Hercynian and Alpine 'revolutions,' something akin to wholesale massacre overwhelmed once successful groups. Even when a group, such as the Trilobites or Reptiles, survived such a storm, it did so in greatly reduced numbers and importance. There are significant exceptions to this common fate. The Ammonoidea, for instance, came through the Hercynian revolution unscathed; but they collapsed at the first rumours of the Alpine troubles. Such exceptions are peculiarly valuable in their relation to the phenomena of evolution, and will be considered later. For the present we can be content to realise that the bulk of evidence points to the fatal effect of environmental change on a large proportion of the flora and fauna exposed to it.

Environment has, then, a powerful influence for destruction; but the question as to its effect, if any, on the introduction of new types to replace its victims is not so easily answered. The record of palæontological succession certainly shows this replacement to be speedy and thorough. The collapse of the Nautiloids in Hercynian times was compensated by the rise of the Belemnoids, and the retirement of the Reptiles was followed almost at once by the advance of the Mammals. The world seems never to wait long for a full complement of novices to replace fallen veterans.

One partial explanation of this is clear. Physiographical changes, by depleting the ranks of the current population, reduce the incidence of the biological factor of the struggle for existence, so that active competition is temporarily abated. Without competition, the offspring of the survivors have better individual chances of life, and multiplication with its accompaniment of variation will be almost unrestrained. This explanation, like most of its kind, leaves the main problem unanswered. It fails to show why conditions that were fatal to one group should stimulate another with similar habits and needs; and it leaves open the question as to the selection of one group for destruction and another for advancement. Surely, if depletion of the population improves individual prospects for the offspring of one race, it should have the same beneficent influence on the next generation of any other with similar propensities, including the race that has just been decimated. It would be absurd to postulate that a group of organisms living and flourishing in all parts of the world could have been immolated at one fell swoop by a universal cataclysm; so that there must be some other factor that decides between the doomed and the preferred. For the moment we must defer further discussion of this difficulty.

The longevity of some types of organisms as compared with others shows clearly that some are less susceptible to the lethal influence of environmental change than others. We have already seen that the types that weather the storms of time are those with relatively simple structures, while those prone to collapse before them have more complex structures. Both types of structure agree in their admirable suitability in an appropriate environment; but it is obvious that a wider range

of conditions can be appropriate to simple structures than to complex. Indeed, we may go further, and conclude that simplicity implies catholicity and complexity implies specialisation. A simple type, with simple needs, is long-suffering under change; a complex type, with peculiar needs, is distraught if those needs are not met in their entirety. A Jack-of-all-trades has a better prospect of finding a job than a specialist.

This principle, while explaining the longevity of simple types, can only explain the shortness of the careers of complex types if we assume that such types are incapable of modification consonant with changes of environment. Although there are very many cases where a stereotyping of structure has undoubtedly had a fatal sequel for this very reason, there are also cases where highly elaborate types have come through physiographical crises unharmed. One of the most notable of these cases is found in the Ammonoidea. The Permo-Carboniferous members of that group were at least as complex in structure as any before or since that time, but the Hercynian revolution had little or no effect upon their quality or dominance. Their success is made the more dramatic by the spectacular collapse at about that time of the Nautiloidea, an allied group with much the same habits of life. Evidently complexity is not necessarily fatal, although it is more dangerous than simplicity.

In an endeavour to find an explanation for the patent fact of varying reaction to environment, recognition of the principle of evolution becomes inevitable. If all types were irrevocably fixed in character, the meek would long ago have inherited the earth; all complex and specialised types would have met their doom during the succession of geological changes. But in fact, although a steady undercurrent of simple types flows unchecked through the record of palæontological history, the frequent and spectacular disasters, like the bursting of bubbles, that have befallen the complex types have but opened the way for others of equal complexity to rise to the surface.

One of the most stimulating glimpses into the mode of evolution was given by the work of Alpheus Hyatt and his successors, notably C. E. Beecher and R. T. Jackson. The main thesis of their interpretation consists of a kind of extension of the neontological theory of recapitulation to fossil forms. When recapitulation was found to continue after the embryonic or larval stages, and to persist throughout the life of an individual, a much more satisfactory element was brought into the theory. Larval stages are often passed under conditions that could never have been tolerated by the adult forms that they are supposed to recall; whereas there is no reason why an adolescent or adult individual should not occupy an environment similar to that of its ancestors. Moreover, the relatively slow rate of growth and development after the larval stage makes the discrepancy between the speed of evolution and that of ontogeny less intense.

By application of this principle, especially to the cases of Ammonites



and Brachiopods, Hyatt and Beecher were able to find the adult characteristics of later types represented in the adolescent stages of earlier ones. They found in the growth-stages of a single individual a succession of characters that agreed with the palæontological succession of its kindred. R. T. Jackson applied the method of study to Pelecypods, and enlarged the scope of the theory by his recognition of 'localised stages in development' in forms, such as Echinoderms and Plants, where early features are modified or destroyed during life.

Although the principle of perpetual recapitulation has stimulated a vast bulk of palæontological research, it has scarcely attracted among neontologists the attention it deserves. Work along these lines on recent material has generally been done by palæontologists, for there still exists a perverse tendency among neontologists to give but scant attention to the hard parts of their victims. Especially does one note with regret that developmental studies seem, for the most part, to stop when the embryo is hatched, even if they extend beyond gastrulation.

Just as a blind faith in the infallibility of embryological recapitulation led to such absurdities that the whole principle was in danger of discredit, so uncritical acceptance of Hyatt's principle of post-larval recapitulation has at times been brought into disrepute. Especially has this occurred when developmental stages were accepted as evidence of phylogenetic descent without the precaution of checking the assumed succession by field evidence. The order of occurrence, like the order of superposition in stratigraphy, must always be the final test of any scheme based on other evidence. It must be admitted that the formidable, and largely unnecessary, terminology whose invention seems to have been a passion with Hyatt, made unpalatable and obscure the facts that it was designed to elucidate; and also that some of the illustrations he used were unfortunately chosen. But no amount of criticism or scepticism can vitiate the discoveries of Branco, Beecher and Carruthers; the principle is sound even if some of its exponents have been mistaken.

Post-larval recapitulation, with its extension into senile prophecy, provides a link between racial evolution and individual life. Most of Hyatt's terminology was based on analogy with individual life; the seven ages of man became symbols of the stages of morphogeny and phylogeny. In its fullest implications, it completes the tale of the uniformity of natural laws working on different scales. Just as the history of a family is similar to, but longer than, that of one of its component genera, and that of a genus than that of one of its species, so the evolution of a species is shown in an abbreviated and bowdlerised form in the life of one of its individual members. Inception and extinction of species have their counterparts in the birth and death of an organism, and the phases that intervene can be matched in each case. It is usual, and proper, to speak of a genus or species as representing an early or late stage in the evolution of its line; it is often possible to demonstrate that these terms have the same sort of significance as the words young or old when applied to individuals. In short, the delightfully simple conception emerges that the life of an



individual is to all intents and purposes the evolution of its species seen through the wrong end of the telescope; or conversely that the evolution of a species (or any larger group) is but the life of one of its members extended into geological perspective.

This generalisation may appear to some to suffer from over-attractiveness; it seems too simple to be true. Such an attitude would imply that individual life is simple—an absurd travesty of the truth. But even if it were, the history of all scientific research teaches that simplicity is a characteristic of Nature, and complexity a reflex of human ignorance. In the physical world a few simple principles work uniformly on galaxies and atoms; it is only to be expected that in the organic world there should be a common control of the lives of phyla and cells. The same law of dynamics controls a see-saw or the Tower Bridge; why should not one law of evolution apply equally to individuals and to the races to which they belong? These arguments seem reasonable, but they would be mere sophistry were not the facts of Palæontology explicable on no other assumption. In the light of our knowledge, we are justified in declaring that the way 'life' is lived is the way of evolution, whether it be from the Cambrian to the Holocene or from the cradle to the grave.

It is unnecessary to enlarge upon the corollary to this conception. If all living things are in continuous contact with varying conditions, those that are adaptable will enjoy greater prospects of success than those that are stereotyped. Youth implies plasticity, and old age is synonymous with stiffness. Whether physically or mentally, the young are flexible, the old more rigid; changes of circumstance that stimulate a youth will kill his grandfather. In evolution this means that a group will, in its early stages, be able to keep pace with, and be moulded by, its changing environment, while when it has passed its prime it will be in deadly danger from similar changes. Although we are far from an understanding of the mechanism by which this result is attained, the result itself, and its causes, are repeated a myriad times in the palæontological record.

In view of the fragmentary evidence afforded by Palæontology, any attempt to produce a 'genealogical tree' for an individual or group must be largely speculative, and of doubtful value. It is hard enough to trace the descent of human beings whose ancestors were born in recorded wedlock; but the mating of most creatures, particularly of marine invertebrates, achieves a degree of promiscuity unattained even in Hollywood. Nature is no stud-farm; and, although there are stern laws to limit hybridisation, cross-breeding is infinitely complex. Those who seek to detect lineages among fossils are seeking the non-existent.

In his address to this Section in 1920, my late friend and mentor Dr. F. A. Bather laid stress on the distinction between succession and descent. He illustrated the danger of confusing the two concepts by reference to the succession of English sovereigns, where logical adherence to a well-founded theory of descent would 'make James I the son of Elizabeth.' This mistake would be disreputable in the light of known facts; but, with all deference to the memory of the Virgin Queen, it would

be immaterial in palæontological perspective. Both James and Elizabeth were of royal 'blood,' and were indeed fairly closely akin. There were many strands common to the tangled ancestry of both; and, since they belonged to successive generations, Elizabeth could, without disrespect or inaccuracy, be described as *in loco parentis* to James. Perhaps this idea can be expressed more clearly by prolonging Dr. Bather's analogy. A glance at Cromwell's portrait or behaviour would suffice to show the improbability of his having been the son of Charles I; and even a palæontologist would see in him the introduction of a new lineage. With the coming of Charles II a manifest restoration of the earlier lineage is evident; and the question as to whether he was the son, grandson or nephew of Charles I is of minor importance.

Among fossils, a lineage must be considered as a succession of members of a freely interbreeding stock; no more precise definition is possible or necessary. Even then it has but a theoretical interest; in reality the only lineages that can be detected are those of morphogenetic succession.

The palæontological evidence of evolution is complicated by the incidence of environmental change. So subtle and complete is the sympathy between structure and environment that there is a point of view that claims environment, and its corollary the 'struggle for existence,' as a determining factor in, if not a prime cause of, evolution. If, however, we accept the view that environment is an educator, such glorification of its influence appears ridiculous. Education can transform an ignorant child into a learned man, or a normal flea into a performing one; but it cannot change a gorilla into a chimpanzee nor a whippet into a race-horse. Common sense shows that there must be limits beyond which the call of environment is powerless to evoke response.

There is a vast body of evidence to show that evolution is, in some measure at least, independent of the incidence of environment. The most satisfactory evidence of this nature is to be found in the fauna of the Chalk. There, in the stillness of the floor of an open sea, conditions remained constant (save for slight temporary irregularities in the depth of the water) for a very long period of time. Many groups of animals persisted through considerable parts of the Chalk stage, and it is reasonable to assume that their representatives in the successive layers of the Chalk are in as direct lines of descent as can ever exist. When we discount slight, often transient, differences of shape that can be correlated with bathymetrical changes, we find clear proof of continuous and directional evolution in many characters. The case of the genus *Micraster* is classical; but those of *Echinocorys*, *Conulus*, *Bourgueticrinus* and *Inoceramus* are equally convincing. In a later paragraph I propose to use *Micraster* as an illustration of many important phenomena of evolution.

The two striking aspects of the nature of morphogeny as shown by 'inch-by-inch' collecting of fossils from the Chalk are, first, the intrinsic character of the successive changes and, second, their directional quality. The course of evolution, seen in a long succession free from appreciable external influence, proves to be straight, or at least direct. Whether



its direction was predetermined at the outset, or whether it was induced and selected by circumstances at an early stage, we cannot tell; but when once it has been fairly started, it continues inexorably to its limit. It must be admitted that this view of evolution is out of favour with many neontologists, to whom the word 'orthogenesis' is anathema. The attitude of these critics has a precedent in that of the physicists of a past generation who were convinced that the sun could not have existed long enough for geological history to have happened. Inability to explain a fact is no evidence of its fallacy; and palæontologists can proceed unruffled to record the facts of orthogenesis.

Whatever may be the influence, direct or indirect, of environmental changes on the course of evolution, there is certainly this other factor at work. The several organs of an organism have considerable independence, although they must keep a harmonious balance if disaster is to be averted. In the nature of things, palæontological evidence is most adequate for appreciation of the evolution of such structures as shells. These external organs are at once intimately concerned with the environment, and capable of much modification without affecting the welfare of the organism of which they are a part. The dual nature of morphological evolution in cases of this kind is very clearly shown in the *Ostrea-Gryphæa* lineage worked out by Trueman.

If we consider a flat oyster-shell, such as *Ostrea liassica*, affixed by the greater part of one valve, two obvious imperfections appear. Only a limited number of individuals can occupy a definite space if they have this posture; and the valves will open near 'ground-level' where the water may be gritty. Whether by some intrinsic impulse, or by selection of chance variations, such a type of oyster tends, in the course of many generations, to reduce the area of fixation, and, by curving the released part of the valve upwards, to reach purer and less crowded water. In course of time this tendency is pushed back into earlier stages of development, until a type appears which is fastened by a very small area only, and in which the direction of growth has been rotated through 90 degrees. In this state the oyster has rectified both of the disadvantages inherent in its first condition, for now many shells can stand erect where previously one lay prone, and all open into the water above the mud-level.

So far in the story (which is demonstrably true) it is possible to invoke the influence of environment as a causative and selective influence. But the story does not end here. Gradually, in direct continuation of what had happened hitherto, the area of fixation becomes more and more reduced and the curvature of the shell more pronounced, until once again the opening of the valves is bent downwards towards the sea-floor, and the area occupied by the individual is again large. Still, as we follow the sequence, the rotation continues, until the final spot of fixation is obliterated, and the shell, with one valve curved through a semicircle, lies loose. Freed from the restraint of fixation, this valve becomes progressively more enrolled, until it assumes the familiar spiral form seen in *Gryphæa incurva*. As a compensation for freedom, and the inconvenience and danger thereby caused, the enrolled part of the valve becomes enormously thickened, so as to ensure uprightness of posture by the same



principle as that used in celluloid dolls with leaden bases. Once more the shell stands upright, and all seems well. But the tendency to secrete great quantities of carbonate of lime becomes, as Lang has shown in the case of Polyzoa, an obsession. A full-grown *G. incurva*, when opened, shows very little accommodation for the oyster in contrast to the bulk and massiveness of the shell. With progressive increase in solidity, and continuous further curvature of the once fixed valve, the shell becomes unwieldy, and that particular lineage of oysters disappears.

The tragic story of *Gryphæa* is in no sense unique, nor is it of a kind peculiar to Mollusca. An exactly parallel case, or series of cases, can be found among the Brachiopoda. The story of *Productus* could be told in almost the same words as that of *Gryphæa*; while there is hardly a family of Brachiopoda that does not include some types in which undue curvature of the ventral valve has obliterated the pedicle. Whatever ingenious devices may have been employed to compensate for this condition, by local weighting or spinous growths or coral-like cementation, there was no long future in store for a Brachiopod stock that dissipated its birth-right by destroying its pedicle.

We have, of course, no direct evidence as to the changes, if any, that occurred in the soft structures of oysters and Brachiopods whose shells underwent such alterations. Probably some readjustment would be needed to fit the change of posture, but it need not have been drastic. It is, however, evident that the utmost perfection and efficiency of all the other organs would avail nothing if and when the shell became unmanageable. Heart-failure will kill an otherwise healthy body.

The account of morphogenetic evolution can be extended and amplified by a further 'Analysis of the Genus *Micraster*.' Rowe's work on this type, although not the first of its kind, deserves to be regarded as a classic in evolutionary studies. Perhaps its chief value lies in its avowedly stratigraphical aim; the chronological succession was recorded without regard to any possible biological implications. Moreover, an Echinoid is an exceptionally satisfactory type for palæontological study. Its hard parts include a great variety of structures, and the mesodermal and yet peripheral character of its test ensures intimate association with the living tissues and close contact with the environment. For our present purpose it will suffice to select three distinct structures of the test, and to consider only the simplest aspect of their progressive modification during the period of the Upper Chalk.

The interporiferous tract of the ambulacral petals is almost smooth in such types as *M. corbovis* and *M. leskei*, species from the base of the Upper Chalk. In the highest zones to which the genus persists, these tracts are highly ornamented with granules, and marked by a pronounced groove along the median line. Every gradation between these two extremes can be found; and, in spite of occasional slight irregularities, the chronological sequence of the gradations is remarkably straightforward. It is not easy to suggest any functional difference of vital importance that this change could indicate; rather the steady increase in elaboration seems

a wholly gratuitous embellishment. It may well have had a significance that will be mentioned in the following paragraph ; but taken on its own merits it seems to show a trend of evolution as automatic as unnecessary.

The thickness of the test of *Micraster* is another progressive character. *M. corbovis* has a very thin test in proportion to its not inconsiderable size, while at the upper extreme *M. rostratus* has a smaller but much thicker test. Again the chronological sequence is almost perfect from thin to thick. In this case various reasons can be postulated for a change that cannot have been wholly without influence on the bionomics of the animal. It has been suggested that life in an environment of calcareous ooze made absorption and secretion of calcite a sort of disease. This suggestion, however, leaves quite unexplained the delicacy of the tests of several of *Micraster's* contemporaries and associates, and the extreme flimsiness of many recent sea-urchins that live in comparable surroundings. Explanations based on variation of depth of the Chalk sea are no more satisfying, for that quality undoubtedly fluctuated, while the thickening of the test is steadily progressive. There is, in short, no sign that this character was either enforced by the environment or advantageous to the animal, but it developed notwithstanding. By analogy with the case of the petaloid ornament, we might suggest that the building of a test (that is, a tendency to secrete calcite) was a quality which, once started, continued regardless of convenience or necessity. Perhaps this is no analogy, but all part of the same story ; for the packing of the interporiferous tract with granules until it is flush with the surface of the test may well indicate a storage of surplus calcite in a place where it would be least in the way. Since a similar embarrassment of mineral wealth seems to overwhelm a large proportion of the organisms that come within palæontological reach, it may be taken as provisionally true that mineralisation, however useful it may be in moderation, becomes gradually a disease.

The third character in the test of *Micraster* that we can select for analysis is that of the labrum, a shovel-like prolongation of the ' lower ' lip of the peristome. In this feature progressive change is again in evidence. Low-zonal species have a scarcely recognisable labrum, while in high-zonal forms the structure may be so strongly developed as to project beyond the anterior end of the body. There can be no question that, for an animal with the habits of a *Micraster*, a well-developed scoop is an aid to efficiency in feeding. The food-bearing ooze or silt is, in part at least, directed towards the mouth by the anterior sulcus of the test, and any device at the peristome to ensure its entry into the mouth would avoid waste. It seems reasonable to conclude that some stimulus, possibly that of friction during use, encouraged the initiation of a labrum, and that the labrum continued, perhaps under the same stimulus, to increase in size as one generation followed another. Such a suggestion raises the spectre of the inheritance of acquired characters ; but this is not the place to worry about warring hypotheses. The fact is that the genus *Micraster* began with practically no labrum, and that that structure progressively increased in size as time went on. But (and here is the significant feature), after the labrum had reached adequate proportions, it continued to grow until, in the latest types, it had so far outgrown



its functional value as to project beyond the anterior sulcus into a position of maximum risk and minimum usefulness. Almost immediately after that stage was reached, the genus *Micraster* disappeared and was no more seen.

Here again we are driven to the conclusion that a structure, once initiated with the best intentions in the matter of utility, continued to increase regardless of its own efficiency or the welfare of the organism of which it was a part.

Lastly in this connection, we can record a feature in the morphogeny of *Micraster* that often causes difficulty to stratigraphers. When we consider the two outstanding characters of petal-ornament and labrum together, occasional anomalies appear. It is unsafe to use only a fragment of a test for zoning purposes, because the ambulacral character may be either before or behind its 'time' in the succession, and the same condition may apply to the peristomial features. If, however, we find a test with relatively 'low-zonal' ambulacral petals and relatively 'high-zonal' labral structure, stratigraphy will always enable us to prove that the proper chronological place of that specimen is somewhere between the extremes indicated by each character separately. In other words, the *whole* test shows the correct zonal position of the specimen; it is the average result of the conjunction of its various parts. In practice, this leads to a very safe, but scarcely mathematical, usage. A practised eye can tell by a general look at a *Micraster* its correct zonal position, whereas laborious analysis of each character separately often leads to contradictory and confusing results. It is a process closely analogous to our recognition of our human acquaintances: we do not consciously remember (if we ever really knew) every detail of each feature. Even lovers, who may be expected to indulge in fairly close investigation, are not always able to recite a reliable catalogue of the facial peculiarities of the object of their regard.

The general principle that seems to emerge from this scrutiny of some of the features of *Micraster* can be expressed in simple terms. Each character has some measure of independence, and follows a morphogenetic trend (whether of increment or reduction) irrespective of the other characters and even of its own utility. The organism as a whole seems to hold a kind of balance between the several characters, so that if one of them is precocious another will be backward.

Although this principle has been illustrated here by reference to the history of a single genus (and, for the sake of clearness, of a few characters only), it can be recognised in most of the groups of organisms of which we have much palæontological knowledge. In effect, it is merely a statement of the fact of over-specialisation; but it seems to explain in some degree the danger inherent in that disease. For if the function of the whole organism is to ensure a balance between independent and perhaps antithetic trends of evolution among its components, specialisation in one respect must inevitably involve reduction in others. There is no evidence to suggest that the structures that become highly specialised are necessarily the most vitally useful (although if they are of that calibre their over-development will soon neutralise their value); so that over-emphasis of an unimportant or harmful feature must lead to starvation and reduction



of others that may be of vital importance. No organism can thrive unless its components work in harmony ; no harmony can be held for long when the several structures follow their own rates and directions of modulation. Doubtless this self-evident condition affects every component of every organism ; to the palæontologist the note that seems doomed to modulate into discord is that of mineral secretion.

It must be obvious to all that the course of morphogeny just sketched is closely analogous with the history of individual life ; or, for that matter, of political and economic affairs. The whole issue boils down to the simple proposition that structures, organisms or states arise, gradually reach maturity, and then pass beyond it to destruction. An important aspect of the matter, however (again platitudinous, but often overlooked), is that the smaller and unconsidered ingredients may often be the final arbiters. It avails nothing for an organism or a body politic to be in otherwise perfect order if one of its ingredients is out of proportion. An organism or a kingdom, if divided against itself, cannot stand.

There is thus a twofold Nemesis awaiting all living creatures. Environmental change may outpace their powers of adaptation, and so destroy them ; or, if this external disaster is avoided, the means adopted to elude it proceed relentlessly towards a disproportion that means failure. The gloomy conclusion we have now reached implies nothing more unexpected, or more encouraging, than that for races, as for individuals, there exist but two alternatives, natural or accidental death.

We are now in a position to summarise the palæontological evidence as to the manner of evolution. Palæontology gives no direct evidence as to the origin of groups, of whatever taxonomic grade ; its scope is limited to records of the later stages in the careers of groups already in existence. This is not to deny that the presumptive evidence for the birth of new types is overwhelmingly strong ; but actual tangible proof of their parentage and generation is lacking. A palæontologist is more of an undertaker than a midwife.

Again, fossil evidence cannot give convincing demonstration of the origin of structures in organisms ; its scope is restricted to observation of the fate of those structures after they have appeared. There must always be a theoretical quality in attempted explanations of the development of new characters ; there are facts recording what happens to them in course of time.

The only language which adequately expresses the nature of morphogeny is that used in description of individual life. Structures, once originated, pass through stages of development, modification and amplification that are closely analogous to the phases of personal history, both physical and psychological. There is a continuous duplicity, in that intrinsic characters are involved with external requirements ; environment is educative but not creative. There is a limit to the response to environment possible for any structure ; if that limit is exceeded, disaster results. Every character of an organism, like every complete creature, is more responsive to environmental influence in its early history than later. Directions of development induced or encouraged by environment

become gradually ingrained ; just as practices oft repeated become ineradicable habits. In contrast with modern municipal tendencies, trolley-buses are transmuted to trams.

The several characters of an organism are at once independent and inseparable ; each can follow its own line of development, but unless a balance is kept within the whole series, collapse is certain. Just as different groups of organisms show very different evolutionary speed, so the various structures in a single organism become modified at varying rates. The attainment of mature perfection from a stage of immaturity can never be more than a transient phase on the way to a fresh disproportion comparable with senility.

Structures, and with them the organisms to which they belong, grow old, exhausted or hypertrophied by their own intrinsic expenditure of evolutionary ' effort ' amid an ever-fluctuating embarrassment of circumstance.

We come to the conclusion that the oracular recommendation to know ourselves is a guide to the secret of evolution. Physically and (in the human case) psychologically we live our lives as compromises between hereditary tendencies and environmental requirements. As we grow older our accumulated load of compromise becomes an obsession, reducing our capacity for further efforts of the kind ; and our environment never tires in its changefulness.

If we consider these principles in the light of the struggle for existence, we find that those types which can attain the most perfect harmony with their environment will flourish proportionately. But their success brings Nemesis in its train ; for speedy evolution towards dominance implies continuous speed ; the perfection point is passed by the same momentum that reached it. Undoubtedly the victor in the struggle for existence wins the prize : but the prize is death.

When we attempt to apply to human affairs the principles of evolution as shown in Palæontology, many difficulties appear. Not the least of these is the impossibility of a dispassionate outlook ; we are proverbially unable to see ourselves as others see us. Another serious difficulty arises from the shortness of the time during which our species has existed, and the paucity of reliable evidence that it has left of its history.

At the outset we must admit that the basis of our analysis of mankind will be on a different plane from that which we employ in the case of other organisms. Morphological and physiological characters change so slowly that we cannot expect to find much alteration during our brief career ; and in any case there is practically no evidence of that sort available. But if the conclusions already reached as to the universality of the law of evolution are accepted, it matters not a whit which particular attribute of an organism we select for study. Behaviour is but an expression of the reaction between the qualities of an organism and its environment, and civilisation is a kind of behaviour. This argument is not so specious as it may appear, for the evidence available to check its validity is ample.

Before following that line further, it will be well to attempt an estimate of the qualities of the human species as they appear to a palæontologist. This is a dangerous part in this address ; for I am bound to omit, for the



time being, reference to many human attributes. I must appeal for your patience, assuring you that I am as fully aware as any of you of the incompleteness of the analysis I am about to make ; and that later on, in a desperate attempt to arrive at a happy ending, I propose to give consideration to those qualities in man that truly differentiate him from other animals.

If it be asked how a student of ' lower ' orders of organisms (and those defunct) can presume to include the human race in his purview, a plea of justification can be made on two grounds. Mr. Tony Weller gave it as his opinion that ' the man as can form a ackerate judgment of a animal can form a ackerate judgment of anything.' This generalisation, like all others, may be debatable ; but the course of human history, in so far as it is known, shows features typical of the course of evolution revealed by Palæontology.

The outstanding physical peculiarity of the human species is its upright posture, a feature to which many of its bodily structures are far from completely adapted. In spite of its relatively large size, the human body cannot be claimed as exceptionally capable. A man stripped of the instruments of his devising, left to compete on equal terms with the other occupants of his restricted environment, would stand no better chance than they. It is true that he could perform most of the actions expected of land animals, but none of them superlatively well. Were he compelled to rely on his bodily characters alone, there would be little more reason to single him out for special consideration than there would be the capacity to do so.

The mental powers of man are those that place him in a category apart from other creatures. By the exercise of his wits he can find compensation for structural shortcomings, and challenge, defeat and control all other living things. With the help of the machines that he invents, he can project himself successfully beyond the normal range of terrestrial animals, transporting his body and his habits over the sea and through the air. He can, within fairly wide limits, overcome the influence of environment.

With no intent to belittle the mechanical achievements that have brought man to his commanding position, we must admit that few of them can be claimed as original. They are copies, often improved editions, of devices that already existed in the animal creation, coupled with applications of natural forces that are as old as the world. Man's capacity for generalisation has enabled him to foresee the effects of his inventions, and so to reduce the time that would otherwise have been spent on the costly method of trial and error. He can transmit his experiences to his own and following generations, so preventing (for those who listen) a wasteful repetition of mistakes. The speed with which he has beaten all other creatures at their several games is commensurate with the degree of his success. Paradoxically he has become supremely generalised by the exercise of a highly specialised faculty.

It is difficult to find any type of animal behaviour in which man cannot excel. Whether in the strictly mechanical processes, such as locomotion or building, or in the more subtle qualities of affection and aspiration, he stands revealed as an exaggerated animal. There are no activities, constructive or destructive, and no habits, pleasing or loathsome, in which he cannot outdo the most accomplished animal.



This analysis leads to a somewhat equivocal result. On the one hand, the high cerebral specialisation that makes possible all these developments, and the extraordinary rate at which success has been attained, both point to the conclusion that this is a species destined to a spectacular rise and an equally spectacular fall, more complete and rapid than the world has yet seen. On the other hand, the wide range of directions into which the specialisation extends, and the measure of control over environment that it entails, seem to suggest a peculiar kind of plasticity that might pass for generalisation, with the consequent hope of a long time-range. In this uncertainty we must look for such facts as are available, facts of history which are at least comparable with the record of Palæontology. But first we must estimate the relative value of the evidence afforded by human history.

Fossils and historical documents alike give but a fraction of an account of the matters of which they treat. In both cases the story of the early stages of racial progress is imperfect and often mythological; the episodes of decline and fall are more fully documented. But, in contrast to palæontological evidence, human accounts are always suspect. Written records of events represent an impression made on one, or at best a few, minds; they may, indeed they must, be tainted with prejudice and ignorance even when they are not deliberately falsified. The impious rebellion of one writer is the glorious revolution of another. Whatever may be the criticisms levelled at the transcribers of Natural History, no doubts can be cast on the essential truth of the record they try to interpret. As an academic proposition, it may be debated as to whether a misread fact is preferable to a misread falsehood; but there is at least a chance of finding the truth in the former case.

Again, the bulk of human history is the record of the performance of a few actors on a specially selected stage; Palæontology, with all its imperfections, gives a picture of events in fairer proportion. The parts of human history usually recorded represent the activities of man the intensified animal rather than of man the half-fledged angel. The behaviour of the animal is the more rational, and so easier to remember and describe. But from very early times another factor has entered into human affairs—a factor illogical and wayward, but every bit as real to a man as his animal qualities. This factor, which we may call ‘altruistic,’ makes human actions often unintelligible in the present, and still more so in the past. For example, it is easier to find a rational explanation of the presence and characters of a *Micraster* in the Chalk than to form a plausible hypothesis as to the meaning of the Stonehenge that men erected over it. Man can safely claim to be unique, for he is the only irrational creature in the world. A palæontologist may be excused for looking askance at a record of creatures like that written by one of themselves.

Nevertheless, man leaves other traces of his activities besides written screeds, and many of these records are as revealing, and as unintentional, as the shell of a mollusc. By piecing together archæological materials, and fitting documentary accounts into the plan of this mosaic, a conception of human history can be gained that comes within measurable distance

of scientific evidence. We have more established knowledge of the Belemnites than of the Incas, but perhaps we know almost as much about the Romans as about the Trilobites.

It would be wearisome to reiterate the various features wherein the history of human affairs corresponds with the course of evolution in other groups. Whether we consider individual lives, dynasties or empires, the same depressing story applies. Some races, once dominant in their particular sphere, have disappeared entirely; others, fallen from high estate, linger in inglorious decay. But all of those brave civilisations and empires of which we have records seem to have shown a succession of similar histories. They have risen from obscurity through possession of successful attributes, and have reached the peak of their power only to pass it. Some have rotted away quietly, others have fallen before the onset of less rotten stocks or perhaps of extra-human disaster. Many of the early empires were on so small a scale that their rise and fall had merely local effect; others have been more comprehensive, and their dissolution has spread havoc over wide areas of the world.

Until comparatively recently, there has been a persistent proportion of 'backward' types, unaffected by the civilising influence of the progressive powers. These have remained as a quiet background to the transient pyrotechnics of the others. They remained to provide a new upstart when the current one had crashed. To-day there are few races of this kind left; almost all of mankind has encountered civilisation and either perished or been transmuted. The fatal complexity of civilisation grips the whole species, crushing it into unity.

The specific causes of the collapse of once dominant races are doubtless varied; but there is general agreement that one universal factor in disintegration is complexity, an aspect of over-specialisation. The units of an empire, be they individuals or factions, tend to work together in harmony during the period of upward struggle; but when a position of dominance is won, they continue to struggle. When there are no new worlds to conquer they begin to fight among themselves. Selfish aims replace patriotic ones, and the community becomes discordant.

The correspondence between this state of affairs and the morphogenetic trends in other races of animals is so close that it needs no elaboration. Those who deny that human institutions are subject to the laws of organic evolution know either no history or no Palæontology. Many proverbs give epigrammatic statements of the principles of evolution in imaginative terms.

‘ Ill fares the land, to hastening ills a prey,  
Where wealth accumulates and men decay.’

The history of extinct empires, which should be studied as a cautionary tale, is commonly regarded as providing an example to be followed. Human nature has the curious trait of gambling against the laws of cause and effect. We always hope that the fate that befel our predecessors will pass us by. Babylon, Egypt, Rome, Spain all traversed the same track; and to-day we follow in their footsteps hoping to reach some different goal.



If this were all, man's outlook would indeed be dark. According to temperament we might as well sit with folded hands in a darkened room awaiting the inevitable end, or meet the crash with ribaldry and riot. Our peculiar quality of superior mentality seems but a suicidal acquisition, hastening and intensifying the imminent doom. But the human mind is more than a fabricator of evanescent institutions. It can transcend utilitarianism (wherein it but exaggerates animal qualities) and can form idealistic conceptions.

Ideas of chivalry, honour and self-sacrifice have no place in the struggle for existence ; but they are inherent in all but hypersophisticated minds. Among ordinary folk, conceptions such as these are stronger incentives to action than animal impulses, as even the most rascally demagogue knows. Learning, philosophy and art are realities to which men will devote their lives, creating rather than copying, with no ulterior or mercenary aim. The arts and virtues bring a new and incalculable feature into the story of evolution. Some, at least, of their achievements outlive kingdoms and empires, seeming immortal.

Men are, for the most part, enthusiastic admirers of virtue, even to the extent of devising laws to ensure its maintenance. Very many of them are actual exponents of virtue in their personal relations ; but in public affairs and in the mass they are often content to behave as animals rather than as men. 'Manners makyth man' is perhaps the most concise specific diagnosis ever published. But there is only one law of evolution, common to individuals and races alike. If mankind as a whole neglects its 'manners,' it abandons any claim it may have to qualitative difference from other animals. There is no doubt of man's ability to become the most successful type of animal that has ever existed ; but the reward of success in that direction is death.

The love of truth, greatest of all virtues, is especially an attribute of men of science. In this we are idealists, for the truth is unattainable, however worth the seeking. We know that all the progress that our species has made, in material as well as in mental affairs, is the result of the search for truth. We find ourselves strangers in a world riddled with more or less blatant deceit ; but we still follow our ideal, confident that all other paths are blind. We recognise in the conception of truth something eternal, not subject to the laws of change and decay.

We know that idealism is the goal and incentive in all actions that can truly be described as human. To the idealist environment is something to be overcome or adapted into service ; the story of human progress is one of triumph over circumstances. The self-styled 'realist,' who advocates acceptance of, and submission to, his temporary environment, is less than a man ; he follows in the tradition of the beasts that perish.

To idealists Palæontology has no message, save to welcome them as something new in Nature. To realists, who seek material success in the struggle for existence, Palæontology, with millions of years of history as its authority, declares emphatically 'You have been warned.'



## SECTION D.—ZOOLOGY.

# NATURAL SELECTION AND EVOLUTIONARY PROGRESS

ADDRESS BY

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### THE MULTIFORMITY OF EVOLUTION.

BIOLOGY at the present time is embarking upon a phase of synthesis after a period in which new disciplines were taken up in turn and worked out in comparative isolation. Nowhere is this movement towards unification more likely to be fruitful than in the many-sided topic of evolution; and already we are seeing its firstfruits in that reanimation of Darwinism which is such a striking feature of post-war biology.

With the reorientation made possible by modern genetics, evolution is seen to be a joint product of mutation and selection. Contrary to the view of Darwin and the Weismann school, selection alone has been shown to be incapable of extending the upper limit of variation, and therefore incapable by itself of causing evolutionary change. Contrary to the views of the more extreme mutationists and the believers in orthogenesis, mutation alone has been shown to be incapable of producing directional change, or of overriding selective effects. The two processes are complementary.

The students of a particular aspect of evolution are prone to think that their conclusions are generally applicable, whereas they usually are not. The palæontologists unearth long evolutionary series and claim that evolution is always gradual and always along a straight course, which may be either adaptive or non-adaptive. However, as Haldane has pointed out, their conclusions apply almost entirely to abundant and mostly to marine animals. In some land plants, on the contrary, we now have evidence of a wholly different method of evolution—namely, the discontinuous and abrupt formation of new species. And in rare forms the course of evolution will not run in the same way as in abundant and dominant types.

Meanwhile the naturalist and the comparative physiologist are struck by the adaptive characters of animals and plants: to them the problem of evolution becomes synonymous with the problem of the origin of adaptation, and natural selection is erected into an all-powerful and all-pervading agency. The systematist, on the other hand, struck by the apparent uselessness of the characters on which he distinguishes species and genera, is apt to overlook other characters which are adaptive but happen to be of no use in systematics, and to neglect the broad and obviously adaptive characters seen in larger groups and in palæontological trends.

The palæontologist, confronted with his continuous and long-range trends, is prone to misunderstand the implications of a discontinuous theory of change such as mutation, and to invoke orthogenesis or Lamarckism as explanatory agencies. Since there exist more rare than abundant species, the biogeographer will have to discount the fact that he is dealing mainly with processes irrelevant to the major trends of evolution regarded as a long-range process; while the ecologist and the pure physiologist, appalled by the complexity of the phenomena, are apt to give up any quest for evolutionary explanation.

#### SELECTION IN A MENDELIAN WORLD.

In our attack upon the problem, we must first mention some implications of recent genetics. Essentially, the modern conception may be put as follows. The notion of Mendelian *characters* has been entirely dropped. Instead of a given gene having a constant effect, its actual effect is dependent upon the co-operative action of a number of other genes. Mutations which in one gene-complex are pathological, in another may be perfectly harmless, and in yet another advantageous. The adjustment of such mutations to the needs of the organism may occur entirely through recombination of existing modifiers, or, after a preliminary and partial buffering by this means, the final adjustment may have to wait upon further mutation.

Thus evolution need not occur by a series of sharp single steps; each such step is immediately *buffered* by ancillary changes in genes and gene-combinations. What evolves is the gene-complex; and it can do so in a series of small if irregular steps so finely graded as to constitute a continuous ramp.

When we reflect further that it is theoretically possible for a gene to alter its character radically by mutating step by small step from one multiple allelomorph to another, we shall see that the discontinuity inherent in Mendelian genetics is no obstacle to the visible continuity revealed in palæontological evolution.

Nor is the pathological character of many mutations at their first appearance necessarily a bar to their final evolutionary utilisation by the species. Let us take some examples of this last-named process. The mutant gene *eyeless* in *Drosophila* was originally described as considerably reducing the size of the eyes, in some cases to complete absence, markedly decreasing fertility, and depressing viability. When, however, a stock for eyeless was inbred for a number of generations, it was found that practically all had normal eyes and showed little reduction in either fertility or viability. On outcrossing to the normal wild type and re-extracting the recessives in F<sub>2</sub>, it was found that these once more manifested the original characters of eyeless, though in even more variable degree.

The explanation of these facts is that the manifestations of eyeless are readily influenced by other genes, and that in general those modifiers which make for normal viability and fertility also make for normality in eye-size. Thus natural selection acting upon the recombinations of modifiers present in the stock speedily saw to it that the combinations



making for the manifestation of reduced eyes were eliminated. In competition with the wild-type allelomorph, eyeless would be eliminated ; but in stocks pure for eyeless, the genes to be eliminated will be the plus modifiers of the mutation.

Selection of this type, it now appears, is a constant and indeed normal process. It has become almost a commonplace in animals used for genetic analysis to find that mutant types which at first are extremely difficult to keep going, after a few generations become quite viable. This has repeatedly occurred in *Gammarus*, for instance, as well as in *Drosophila*, and is also known in mice and nasturtiums. The explanation is essentially similar to that for the case of eyeless.

R. A. Fisher has extended this concept to explain dominance and recessiveness in general. Mutation is always throwing up new genes ; the majority of these will inevitably be deleterious, and will also be repeatedly produced. Obviously the great majority will be carried in single dose, so that it will be an advantage to minimise any activity shown by them while in this heterozygous state. Thus a harmful mutation will inevitably be forced into recessivity by selection acting on the rest of the gene-complex. Haldane has given a somewhat different explanation of the origin of the recessive character of most mutations, based upon multiple allelomorphism ; but this too involves selection acting upon other genes than the mutant. On either hypothesis, dominance and recessiveness are to be regarded as modifiable characters, not as unalterable inherent properties. Dominant genes, or most of them, are not born dominant : they have dominance thrust upon them. Mutations *become* dominant or recessive, through the action of other genes in the gene-complex.

There remains the difficulty that most mutations so far investigated are deleterious. If mutations are the raw material of evolution, some of them in some cases must be, or must become, advantageous. However, this also is not so serious as at first sight appears. Since the gene-complex is an elaborately co-ordinated system, any changes in it are much more likely to act as defects rather than as improvements. Further, the larger the change the less likely is it to be an improvement ; and inevitably the geneticist will detect large changes more readily than small. Recent analysis, however, has revealed numbers of gene-differences with extremely small effects, down almost to the limit of detectability. It is not only possible but probable that among these are to be sought the chief building blocks of evolutionary change, and that it is by means of a series of small multiple-allelomorphic steps, each adjusted for viability and efficiency by changes in the genic background, that an organism usually achieves gradual but well-defined alteration.

But in addition to the initial or intrinsic usefulness of certain small mutations, we have also the fact that mutations which are deleterious in what may be described as normal conditions may become advantageous either in an altered environment or in an altered genic background, and the further fact that many mutations or Mendelizing variations cannot be described as intrinsically useful or harmful, but vary in their selective effects with variation in environmental conditions.

Let us take a few illustrative cases. In conditions near the optimum, the vestigial-winged mutant of *Drosophila* is much shorter-lived than the wild



type. But if vestigials and normals are kept together without food and water, the vestigials survive longer. Thus, in environments which occasionally become very unfavourable, the vestigial type might even oust the normal.

In dandelions, Sukatschew has carried out elaborate experiments on a number of pure lines. Altering the density of total numbers of plants per plot may completely alter both the survival of the seedlings and the fertility of the survivors, so that a pure line which is inferior in one set of conditions will oust the rest in other conditions. This conclusion is entirely in accord with the work of Stapledon and others showing the effect of varying intensity of grazing on the survival and reproduction of different species and strains of pasture plants.

A striking case of rather a different nature concerns a variety, probably due to mutation, observed in tobacco. The new variety failed to flower until the ratio of light to darkness was altered to correspond with what would prevail in a semi-tropical summer, when it became a better performer than the type. Any competition between mutant and type would thus be decided according to latitude.

I ought also to mention the case, described by Harrison, of the light and dark varieties of the moth *Oporinia autumnata*. The relative abundance of these in a dark pinewood and an adjacent light birchwood is quite different, and so, but inversely, is the intensity of selection, as revealed by the number of wings left by birds. The result is that in the dark environment the dark variety is sixteen times the commoner, in the light environment six times the rarer.

Thus, whatever other processes may possibly be at work, it is clear that selection is constantly operative. A difference in environment may decide between two genes with sharply contrasting effects; quantitative differences in conditions may lead to a complete reversal of advantage between varieties; the gene-complex may be selected so as to protect the species from the deleterious effects of mutations, or so as to minimise the ill effects of an otherwise advantageous mutant. In these and other ways natural selection proves itself to be a pervading, active agency.

Having dealt briefly with the *modus operandi* of natural selection in a Mendelian world, we must now discuss the processes of evolution and the rôle which selection may play in them. Darwin himself happened to confuse the issue by calling his greatest book the *Origin of Species*. Evolution, however, must be dealt with under several rather distinct heads. Of these one is the origin of species—or we had better say the origin of minor systematic diversity. Another is the origin of adaptations. A third is extinction. And a fourth, and in many ways the most important, is the origin and maintenance of long-range evolutionary trends. It is of course true that these all overlap and interlock. None the less, the distinctions are real and important.

### THE ORIGINS OF SPECIES.

First, then, we have the origin of species. It is logically obvious that every existing species must have originated from some pre-existing species, but equally clear on the basis of recent research that it may do so in one of several quite different ways. A single species as a whole may

become transformed gradually until it comes to merit a new specific name. Or it may separate, also gradually, into two or more divergent lines. Sometimes the separation into mutually infertile groups may occur suddenly, but the subsequent divergence may yet be gradual. Or it may hybridise with another species and the hybrid product then, by doubling of the chromosomes (allopolyploidy), give rise at one bound to a new species. Here, instead of one species diverging to form two, two converge to form one. (It is possible that such sudden origins of new species by means of chromosome or genome aberrations may also occur without hybridisation, from a single instead of a dual origin.) Finally, in certain groups of plants, the minor systematics are in an inextricable tangle, so that no two authorities agree even approximately as to the number of species involved and their limitations; in these cases hybridisation, apparently involving many more than two forms, together with recombination, chromosome-doubling, and apogamy, appears to have been and still to be at work. Thus species-formation may be continuous and unilinear; continuous and divergent; abrupt and convergent; or what, following a recent writer, we may call reticulate, dependent on constant intercrossing and recombination between a number of lines, and thus both convergent and divergent at once.

Palæontology provides numerous evidences of gradual specific transformation; these have been preserved almost exclusively in aquatic animals, though also in a few land vertebrates such as the horses; but similar changes must, it is clear, have been generally at work. In some cases at least, as in the shift of the mouth in the sea-urchin *Micraster*, the change seems to have been an adaptive improvement.

Divergent splitting must clearly be postulated on a large scale, if only to account for the rapid increase of the number of forms in newly evolved groups such as the higher placental orders. It is not easy to obtain direct evidence of divergence from palæontology, since this demands good series in two separate but crucial areas. But what without question are different stages of the process are yielded by a study of geographical distribution. This reveals all stages of geographical divergence, from dubious to sharply defined subspecies, and thence on to species and genera.

Physiological subspecies, such as the races of gall-forming insects restricted to different host plants, are of a similar nature, though their distinctive characters are not among those which appeal to the museum systematist.

In all these cases isolation, whether geographical or physiological, is involved. Although sometimes, as in many of the geographical colour-varieties of the mouse *Peromyscus*, the differences seem definitely to be adaptive, in others subspecific distinctions appear as biologically meaningless, as do many specific differences between allied species. We cannot be sure whether isolation simply makes it easier for selection to cause adaptive divergence in relation to local conditions, or whether in some cases at least, by some method as yet obscure, it permits the fruition of mere random and biologically useless variation.

An interesting case in which we must presume the isolation to have been suddenly effective is that of *Drosophila simulans*, which so closely resembles *D. melanogaster* that it was wholly overlooked by the systematists.



Genetical analysis showed that it differed from *melanogaster* in having a large section of one chromosome reversed. This must have occurred suddenly, and, once established in homozygous condition, would inhibit the fertility of any heterozygotes. The bar to fertility once established, other differences between the two types could accumulate, though they are still very slight.

It does not, however, matter in principle whether isolation is effected gradually or abruptly; in any case subsequent divergence will be gradual (except in some of the cases to be described later, where the isolating process itself produces marked differences in appearance).

We often know the approximate date at which isolation of an island has occurred, and can see that, broadly speaking, the degree of divergence is proportional to the time that has since elapsed, as well as to the effectiveness of the isolation. It is thus a legitimate deduction that geographical variation provides us with a cross-section of a temporal process, and that isolational divergence has been constantly operative, throughout evolution, as an agency promoting minor systematic diversity.

The sudden convergent formation of new species as a result of hybridisation has only been established in quite recent years. So far we know of it only in plants. Several cases are known, of which *Primula kewensis* is the classical example; but the most striking is that of the rice-grass *Spartina Townsendi*. This, it now seems certain, is an allopolyploid derived from the crossing of the European *S. stricta* and the imported *S. alterniflora*; most interesting from an evolutionary standpoint is the fact that it is for some reason better equipped than either of its parents, and not only kills them out in competition, but is extending its range beyond theirs. In addition the chromosomal and genetic analysis of various of our most important cultivated plants indicates that they too owe their origin to this process.

The common existence in plants of species within a genus with different multiples of a basic chromosome-number is also proof of discontinuous species-formation. In some cases this may have been due to autopolyploidy, and would be therefore not convergent but divergent.

The two classical examples of reticulate evolution are the roses and the willows, though similar cases exist in other groups of plants in which species-crossing and chromosome or genome aberrations are prevalent. So far it is not known to exist in animals, except in man. Here it assumes a somewhat different form, since the crossing has been between units of lower than specific rank and no complications of polyploidy, apogamy, and the like have intervened. Thus the result is a single species with a unique degree of variability, in which recombination is the major factor. The evolution of such a group is clearly reticulate.

Biologists have realised for some time that the term *species* is loose and difficult of definition. However, whether we can define species or not, or whether we ought to emphasise the distinctions between different kinds of species by refinements of terminology, it remains true that species are genuine biological units. On the other hand, we can distinguish in principle between the causes of their isolation and the causes of their divergence. Groups separated by geographical isolation are species only *in posse*. Their separation into good species is a slow and subsequent process,



accompanying the gradual process of character-divergence. In other cases, such as *Drosophila simulans*, the two groups must be regarded as species from the outset, although they may be indistinguishable in any character save that which isolates them. At the opposite extreme are those cases in which the factor inducing isolation simultaneously produces considerable character-difference. This is so in *Spartina Townsendi* and most cases of convergent and reticulate species-formation. Further character-divergence may of course occur later.

From the standpoint of natural selection, species will then fall into two contrasted categories. On the one hand we have those in which natural selection can have had nothing to do with the origin of the basic specific characters, but merely acts upon the species as given, in competition with its relatives. These include all species in which character-divergence is abrupt and initial. On the other hand we have those forms in which character-modification is gradual. Here natural selection may, and on both deductive and inductive grounds often must, play a part in producing the characters of the species. This helps to bring home the heterogeneity of the processes which we lump together as 'evolution.'

#### ADAPTATION AND SELECTION.

We next come to the origin of adaptations. It has been for some years the fashion to decry the study or even to deny the fact of adaptation. I have not the space to discuss the anti-adaptational attitude; I will only say that I believe it to be a passing fashion, and that, both structurally and functionally, every organism is a bundle of adaptations, more or less efficient, co-ordinated in greater or lesser degree.

How has adaptation been brought about? To-day biology rules out special creation or divine guidance, frowns on entelechies and purposive vital urges, and repudiates Lamarckism.

Most biologists also look askance at orthogenesis *sensu stricto*, as implying the inevitable grinding out of results predetermined by some internal germinal clockwork. As Fisher has cogently pointed out, the implications both of Lamarckism and of orthogenesis run directly counter to the observed fact that the great majority of mutations are deleterious.

There remains natural selection. Before discussing some concrete examples of selection at work to produce adaptation and of adaptations illustrating the work of natural selection, a few general points deserve to be made. In the first place, there is the aged yet perennial fallacy that such-and-such an arrangement cannot be adaptive, since related organisms can and do exist without it. This is, quite frankly, nonsense. It is on a par with saying that electric refrigerators are not useful because many people manage to get on happily without them.

There are numerous possible explanations of such a state of affairs. It may be that mutations in that direction did not crop up, or were not available before the stock started specialising along other lines; there may be differences in the genetic make-up or the environment of the two forms which make such an adaptation less advantageous to one than to the other. For instance, rare species are not likely to show the same adaptations as abundant ones.

All that natural selection can ensure is survival. It does not ensure progress, or maximum advantage, or any other ideal state of affairs. A type may survive by deceiving its enemies with a fraudulent imitation of a nauseous form just as well as by some improvement in digestion or reproduction, by degenerate and destructive parasitism as much as by increased intelligence.

Then we must invoke natural selection whenever an adaptive structure involves a number of separate steps for its origin. A one-character, single-step adaptation might clearly be the result of mutation. But when two or more steps are necessary, it becomes inconceivable that they shall have originated simultaneously. The first mutation must have been spread through the population by selection before the second could be combined with it, the combination of the first two in turn selected before the third could be added, and so on. Most adaptations clearly involve many separate characters, and when we can study their actual evolution with the aid of fossils, we find that it is steadily progressive over tens of millions of years, and must therefore have involved a large number of steps. The improbability is therefore enormous that they can have arisen without the operation of some agency which can gradually accumulate and combine a number of contributory changes: and natural selection is the only such agency that we know.

R. A. Fisher has aptly said that natural selection is a mechanism for generating a high degree of improbability. This is in a sense a paradox, but it expresses epigrammatically the important fact that natural selection is all the time achieving its results by giving probability to combinations which would otherwise be in the highest degree improbable.

This important principle clearly removes all force from the 'argument from improbability' used by many anti-Darwinians, such as Bergson. It helps us also to detect another fallacy. T. H. Morgan, followed by Hogben, has asserted that natural selection merely preserves certain among the hosts of recombinations: in the absence of natural selection, in addition to the known forms of life a vast assemblage of other types would exist which have been destroyed by selection.

Actually this is on a par with saying that we could expect the walls of a room to collapse on occasion owing to all the molecules of gas inside the room moving simultaneously in one direction. Both are of course only improbabilities—but they are improbabilities of such a fantastically high order as to be in fact entirely ruled out. Each single existing species is the product of a long series of selected mutations; to produce these adapted types by chance recombination in the absence of selection would require a total assemblage that would fill the universe and overrun astronomical time.

This is perhaps the place to discuss pre-adaptation. According to this view, variations occur which would be adaptive in some new environment or way of life, and their possessors then find their way into that environment or take up that way of life. However, what we have previously said makes it clear that this can only apply to the early stages of an elaborate adaptation, not to its whole history.

A mutation such as that discovered by Banta for altered temperature-resistance in a Cladoceran may be described as *potentially pre-adaptive*;



and so may that previously mentioned (p. 83), adjusting a plant to another rhythm of light and darkness. Doubtless such potentially pre-adaptive mutations are not uncommon, and may play an important rôle in widely dispersed types, and during periods of changing environment.

That selection can influence adaptive characters is shown by a number of lines of evidence, experimental as well as indirect. Cesnola found experimentally that the colours of Mantids exerted a protective effect in relation to enemy attacks. We have already mentioned the results of Heslop Harrison on the colours of certain moths.

Then there is now a large body of experimental evidence showing that insects with warning colours are on the whole rejected, while those with protective colours are on the whole accepted. One of the most interesting pieces of evidence as to the efficacy of selection in maintaining mimetic adaptation is afforded by unpublished data for which I am indebted to Mr. E. B. Ford. The butterfly *Papilio dardanus* has several mimetic types of female. Random collections were made from two areas. In one of these the models were far more numerous than the mimics, while in the other, on the limit of the models' range, the models were actually less abundant; the actual ratios were 17.6 : 1 and 0.24 : 1. The collections showed that whereas in the former case the mimetic resemblance was very close (mimics classified as imperfect being below 4 per cent.), in the latter it was far from exact (31.5 per cent. of imperfect mimics), and the variability of the mimics much greater.

The evidence that we possess goes to show, first, that selection can be very efficacious in altering the mean of a population within the range of existing variability; secondly, that a relaxation of selection will allow the type to deviate away from adaptive perfection, quite outside the range of variability to be found where selection is more stringent; and, thirdly, that adaptive characters may advantage their possessors in such a way as to exert definite selection-pressure in their favour, and that accordingly selection can have a continuous guiding effect towards adaptive perfection.

#### SOME FALLACIES.

Hère we must turn aside to consider long-range evolutionary trends. It is quite clear that many of these are adaptive. So obvious is this fact that it has found expression in the current phrase *adaptive radiation*. When palæontological evidence is available the adaptive radiation is seen to be the result of a numebr of evolutionary trends, each tending to greater specialisation—in other words, to greater adaptive efficiency in various mechanisms subservient to some particular mode of life. Specialisation continues steadily for a considerable time, which in the higher mammals at least seems to last between ten and forty million years; eventually change ceases, and the specialised type either rapidly becomes extinct or else continues unchanged for further geological periods.

It is hard to understand why the trends seen in adaptive radiation have been adduced as proof of internally determined orthogenesis. Whenever they lead to improvement in the mechanical or neural basis for some particular mode of life, they will confer advantage on their possessors and will come under the influence of selection; and the selec-



tion will continue to push the stock further and further along the line of development until a limit of perfection has been reached.

This limit is usually determined by quite simple mechanical principles. A horse cannot reduce its digits below one per foot, nor can it complicate the grinding surface of its molars beyond a certain point without making the grinding ridges too small for the food to be ground. The selective advantages of mere size, which must often be great in early stages of a trend, will be later offset by reduction of speed, or difficulties of securing sufficient food, or, in land animals, by the relative increase of skeleton. There is a limit to the acuity of vision, the streamlining of aquatic form, or the length of a browser's neck, which can be useful. When these biomechanical limits have been reached, the trend ceases, and the stock, if it is not extinguished through the increasing competition of other types, is merely held by selection to the point it has reached.

The only feature inviting orthogenetic explanation is the directive character of the trends, their apparent persistence towards a predetermined goal. But on reflection this too is seen to be not only explicable but expected on a selectionist viewpoint. Once a trend has begun, much greater changes will be necessary to switch the stock over to some other mode of life than to improve the arrangements for the existing mode of life ; and the further a specialised trend has proceeded, the deeper will be the groove in which it has thus entrenched itself. Specialisation, in so far as it is a product of natural selection, automatically protects itself against the likelihood of any change save further change in the same direction.

However, that this apparent orthogenesis is determined functionally is excellently shown by the evolution of the elephants. These began their career by an elongation of the muzzle involving the enlargement of both jaws and both upper and lower incisor tusks. Before the beginning of the Pliocene, this process had reached what appears to have been a mechanical limit. In the later evolution of the stock the jaws were shortened, the trunk elongated, and the lower tusks abolished. The effective reach of the animal for its food was continuously increased ; but the structural basis was wholly altered. It is impossible to stretch the principle of internal orthogenesis to cover a process of this type.

While on this subject, we may deal with a cognate point, the so-called law of the irreversibility of evolution. This is an empirical fact of palæontology, but that it involves no intrinsic necessity is shown by the experimental findings of Sewall Wright on guinea-pigs. He was able to build up a stock which was in full possession of the hind little toe that the wild species genus, and family, had definitively lost. Thus Nature no more abhors reverse evolution than she abhors a vacuum.

The same principles would seem to apply in general to small-scale adaptations as to long-range adaptive trends, except that since such adaptations frequently concern only one particular function and not the organism's main way of life, it should be easier for evolutionary direction to be changed, and for adaptation to set off on a new tack.

An important difference will be found between abundant and scarce species. In the latter, competition will be more with other species, while in the former it will be more between members of the species

itself. In general this latter or *intra-specific* type of selection is more widespread than the inter-specific.

It is a common fallacy to think of natural selection as first and foremost a direct struggle with adverse weather, with enemies or with the elusive qualities of prey. The most important feature of the struggle for existence is the competition of members of the same species for the means of subsistence and for reproduction. Surprise has been expressed by some biologists at the fact that in New Zealand, domestic pigs which have become feral have, in spite of the absence of predatory enemies, reverted to something like the wild type; but in competition for food and reproduction the leaner and more active wild type must clearly have a strong relative advantage over the fatter and more sluggish domestic forms.

It is another fallacy to imagine that because the major elimination of individuals occurs in one period of life, therefore selection cannot act with any intensity on the phase of minimum numbers. It has, for instance, been argued that because the main elimination of butterflies takes place during the larval stage, therefore elimination of the imagines by birds or other enemies can have no appreciable selective effect, and that therefore any protective or warning or mimetic colouring which they exhibit cannot have any adaptive significance. However, it is the adults which reproduce, and a one per cent. advantage of one adult type over another will have precisely the same selective effect whether the adults represent ten, one, or one-tenth of one per cent. of the number of fertilised eggs produced. The same applies to those plants in which the main elimination occurs during the seedling stage. Selection, in fact, can and does operate equally effectively at any stage of the life-cycle. Further, elimination is far from being the only tool with which selection operates. Differential fertility of the survivors is also important, and in man and many plants is probably the more influential.

#### RATE-GENES AND SELECTION.

But, as Haldane has stressed, the results of selection at one period of the life-cycle may have repercussions on other periods and affect the species as a whole in unexpected ways. Perhaps the best example which he gives is that of intra-uterine selection in polytocous mammals. Here there must be intense competition, since a considerable percentage of every litter dies *in utero* and rapidity of growth must be at a premium. Haldane suggests with some plausibility that any rapidity of pre-natal growth thus acquired is likely to be transferred in whole or in part to post-natal life as well, and that intra-uterine selection may thus help to account for the progressive increase in size seen in so many mammalian lines during their evolution. At any rate, the converse seems to hold, namely that on account of intra-uterine selection it would be impossible for a polytocous mammal to slow down its rate of development. One of the most characteristic features of man is precisely such a slowing down of general rate of development. Without it he could not in all probability have become fully human or biologically dominant. This condition could not have occurred in a polytocous form. It was only after man's ancestors



ceased to have litters and began to bring forth a single young at a birth that the further evolution of man became possible.

The slowing of human development further had numerous corollaries. The typical adult human condition of hair on the head but almost complete absence of hair on the body, the hymen of the human female, and the smooth orthognathous form of the human face and skull appear to be based upon characters automatically transferred from earlier to later stages of the life-cycle.

This general slowing down of man's post-natal development is doubtless due in part to its possessing selective advantage. But, as Haldane points out, it may also be in part the indirect carry-over from a slowing of pre-natal development. In the circumstances of primitive sub-man a fœtus is on the whole better nourished and less exposed to danger than a newborn infant, so that pre-natal slowing is here as advantageous as pre-natal acceleration in a polytocous mammal.

This prolongation of a more protected early phase may also apply to the larval period, for instance in insects with their cœnogenetic larvæ, which are often highly adapted to their secondary mode of life. One need only think of the mayfly with its imaginal phase reduced both in structure and in duration.

Sometimes this reduction is carried to its logical extreme and the adult phase is wiped out of the life-history by neoteny. This has demonstrably occurred in various beetles, and in the axolotl. It has probably taken place in ourselves as well, with the heavy brow-ridges and protruding jaws of our ancestors.

Haldane in an interesting paper discusses these and similar phenomena from the standpoint of the time of action of the genes controlling them. A more comprehensive view, however, would include as still more important the genes' *rate* of action.

A large number (possibly the majority) of genes exert their effects through the intermediation of a process operating at a definite rate. The speeds of processes which such rate-factors control are not absolute, but relative—relative to the speeds of other processes of development and of development in general. It is also found that a decrease in rate of process is in general accompanied by a delay in the time of its initial onset, and *vice versa*. Furthermore, such processes do not necessarily continue indefinitely. Often they reach an equilibrium; when this is so, the level of the equilibrium is correlated with the rate of the process. This is so, for instance, with eye-colour in *Gammarus*, and probably in man. In addition to such rate-factors, others are known which appear only to affect the time of onset of a process and not its rate.

Attempts have been made by representatives of the Morgan school to minimise the importance of these discoveries, by asserting that they constitute only a redescription of old phenomena and add nothing truly new. On the contrary, I would maintain that they are of first-rate importance. I need not go into their bearings upon physiological genetics. Here we are concerned with their evolutionary implications.

In the first place, since rate-genes are common, it is a legitimate provisional assumption that the rates of developmental processes in general are gene-controlled. Further, the simplification introduced into an



analysis of development by the concept of relative rates of processes makes it desirable to try this key first of all when attacking any problem involving development.

It then provides a great simplification of the facts of recapitulation and anti-recapitulation. Whenever the rate of a process is correlated with time of onset and final equilibrium-level, a mutation causing an increase in rate will produce recapitulatory phenomena. It will drive the visible onset of the process further back in ontogeny, will add a new 'hypermorphic' character at the end of the process, and will cause all the steps of the original process to be recapitulated, but in an abbreviated form, during the course of the new process. This will account, for instance, for many of the recapitulatory phenomena seen in the suture lines of ammonites.

Conversely, a mutation causing a decrease in rate will have anti-recapitulatory effects. It will prolong the previous phase longer in ontogeny, it will not only slow the process down but stop it at a lower level of completion, and it will remove certain previous adult characters and push them off the life-history. Many of the phenomena of so-called 'racial senescence' in ammonites, including the gradual uncoiling of the shell, may be due to phenomena of this type.

As de Beer has pointed out, when cœnogenetic changes occur in the embryo or larva, the adult remaining unchanged, neither palæontology nor comparative anatomy would register any phylogenetic advance. But if now neoteny or fœtalisation occurs, the old adult characters may be swept off the map and be replaced by characters of a quite novel type. This process he calls *clandestine evolution*. Garstang has suggested that it has operated on a large scale in the ancestry of vertebrates and of the gastropods.

A clear-cut small-scale example comes from the snail *Cepea*. Its non-banded varieties are produced not because their genes cause the total absence of pigment, but because they slow down pigment-formation and delay its visible onset relatively to general growth, to such an extent that growth is completed before any pigment can be formed.

This is a comparatively unimportant effect; but when major processes are affected such as metamorphosis, sexual maturity, or general rate of growth or development, the results may be far-reaching. Pædogenesis is caused by relative acceleration of the processes leading to sexual maturity. Neoteny in the axolotl and presumably in insects is due to the slowing down of the processes leading to metamorphosis. The condition seen in man should not strictly be called neoteny, but rather fœtalisation, or perhaps juvenilisation: this would seem to be produced by a general slowing of developmental rate, relative both to time and to sexual maturity.

The existence of rate-factors has an important bearing upon the problem presented by apparently useless characters. For alterations in the rate of a process will often automatically produce a number of secondary and apparently irrelevant effects. Numerous examples of such 'correlated characters,' as Darwin called them, are now known.

I will take a simple example from *Gammarus*. Here, the depth of eye-colour depends upon the rate of deposition of melanin. But it depends

also on eye-size—when the eye is smaller, the melanin is more crowded and the eye looks darker. Thus a mutation affecting the relative rate of eye-growth alters the depth of eye-pigmentation.

It would seem inevitable that many of the apparently useless features used in diagnosing species are correlated characters of this type. Not only this, but the development of such correlated characters during evolution may simulate orthogenesis. One of the most convincing bits of evidence for orthogenesis was the discovery of Osborn that horns of the same type arose independently in four separate groups of Titanotheres. The study of relative growth, however, has provided a simpler explanation. The horns of Titanotheres are, like most horns, allometric, increasing in relative size with the absolute size of the animal, and not appearing at all below a certain absolute size. Given the potentiality of frontal horns in the ancestral stock, their independent actualisation in the different groups becomes inevitable so soon as a certain threshold of body-size is reached. Increase of body-size is probably advantageous up to a limit; if so, the horns are the useless correlate of a useful character. It would be more accurate to say *initially useless*, since presumably once they appeared they were employed in fighting. That they later became useful is rendered probable by the brilliant analysis of Hersh, who has shown that after a certain period in their evolution the allometry of the horns became intensified.

Generally speaking, change in absolute size is almost certain to produce numerous correlated changes in proportions, and change in relative size of an organ is quite likely to be accompanied by correlated changes in various characters. In addition, continued increase in absolute size will so increase the relative size of an allometric organ that it will eventually approach the boundary of disadvantage. Selection may then operate to reduce its rate of growth, or, if conditions alter rapidly, the organism may be caught napping in an evolutionary sense, and be extinguished. This may apply to the antlers of the Irish elk and the fantastic horns of some beetles.

The claim that the concept of rate-genes is important would thus seem to be justified. It has illuminated the evolutionary aspect of recapitulation, neoteny, foetalisation, clandestine evolution, and apparently useless characters, as well as helping to a simpler understanding of the innumerable cases of quantitative evolution.

### THE RESULTS OF SELECTION, GOOD AND BAD.

Examples such as those of polytocus mammals, of abundant versus rare species, and of allometric organs, show how the type and course of evolution may be altered according to the type of organism or of biological machinery on which it has to work. We may mention a few other cases to illustrate this general principle. The most striking is, I think, that of the social insects. Haldane has demonstrated that only in a society which practises reproductive specialisation, so that most of the individuals are neuters, can very pronounced altruistic instincts be evolved, of a type which 'are valuable to society but shorten the lives of their individual possessors.' Thus, unless we drastically alter the ordering of our own



reproduction, there is no hope of making the human species much more innately altruistic than it is at present.

Another example concerns the reproduction of the higher plants. In them the pollen-grains may be affected in various ways, including the rapidity of their growth down the style, by the genes they bear. As a result of this, certation, or a 'struggle for fertilisation' between genetically different types of pollen-grain, often occurs. Nothing of the sort, however, appears to take place in the sperm of higher animals, where the genes exist in a condensed and apparently inactivated form. Thus genes for rapid pollen-growth will be at a premium in plants, and their effects may spill over into other phases of the life-history; whereas in animals no such effects can occur.

It is a common fallacy that natural selection must always be for the good of the species or of life in general. In actual fact we find that intra-specific selection frequently leads to results which are mainly or wholly useless to the species as a whole. The protection afforded by a cryptic or a mimetic resemblance of moderate accuracy might approach the limit so far as its value to the species is concerned, if there were any way in which selection could be restricted to effects on the species as a species. Actually intra-specific competition between individuals will often lead to the process of adaptation being continued until almost incredibly detailed resemblances are reached—for instance, in some of the leaf-butterflies. Such 'hypertely' is sometimes held up as a disproof of natural selection. In point of fact, it is to be expected from natural selection when intra-specific.

In other cases intra-specific selection may even lead to deleterious results. This is especially true with intra-sexual competition, between members of the same sex of the same species. When polygamy or promiscuity prevails, the selective advantage conferred by characters promoting success in mating will be very high indeed; and accordingly in such forms (for instance, peacock and Argus pheasant) we meet with male epigamic characters of the most bizarre sort which, while advantaging their possessor in the struggle for reproduction, must be a real handicap in the struggle for individual existence. In such cases, of course, a balance will eventually be struck at which the favourable effects slightly outweigh the unfavourable; but here again extinction may be the fate of such precariously balanced organisms if the conditions change too rapidly.

We may, however, go further and proclaim with Haldane that intra-specific selection is on the whole a biological evil. The effects of competition between adults of the same species probably, in his words, 'render the species as a whole less successful in coping with its environment. No doubt weaklings are weeded out, but so they would be in competition with the environment. And the special adaptations favoured by intra-specific competitions divert a certain amount of energy from other functions.'

Intra-specific competition among pollen-grains has led to a real over-production of pollen by anemophilous plants; intra-sexual competition among male mammals has led to unwieldy size or to over-developed weapons and threat organs; intra-specific competition among parasites has led to their often monstrous exaggerations of fertility and complications of reproductive cycle.



There can be little doubt that the apparent orthogenesis which has pushed groups ever further along their line of evolution until they are balanced precariously upon the edge of extinction, is due, especially in its later stages, to the hypertely induced by intra-specific competition.

This conclusion is of far-reaching importance. It disposes of the notion, so assiduously rationalised by militarists and *laissez-faire* economists, that all man needs to do to achieve further progressive evolution is to adopt the most thorough-going competition: the more ruthless the competition, the more efficacious the selection, and accordingly the better the result. But we now realise that the results of selection are by no means necessarily 'good,' from the point of view either of the species or of the progressive evolution of life. They may be neutral, they may be a dangerous balance of useful and harmful, or they may be definitely deleterious.

Natural selection, in fact, though like the mills of God in grinding slowly and grinding small, has few other attributes that a civilised religion would call divine. It is efficient in its way—at the price of extreme slowness and extreme cruelty. But it is blind and mechanical; and accordingly its products are just as likely to be æsthetically, morally, or intellectually repulsive to us as they are to be attractive or worthy of imitation. Both specialised and progressive improvement are mere by-products of its action, and are the exceptions rather than the rule. For the statesman or the eugenicist to copy its methods is both foolish and wicked. Not only is natural selection not the instrument of a God's sublime purpose: it is not even the best mechanism for achieving evolutionary progress.

#### EVOLUTIONARY PROGRESS.

This question of evolutionary or biological progress remains. I have discussed elsewhere at some length the meaning to be attached to this term, so that here a few points will be sufficient. In the first place, it is not true that the use of the word progress is a mere anthropocentrism. There *has* been a trend during evolution which can rightly be called progressive and has led to a rise in the level of certain definable properties of organisms. The properties whose rise constitutes biological progress can be defined in the broadest terms as control over the environment and independence of it. More in detail they consist in size and power, mechanical and chemical efficiency, increased capacity for self-regulation and a more stable internal environment, and more efficient avenues of knowledge and of methods for dealing with knowledge.

One-sided progress is better called specialisation. For progress must not merely be defined *a priori*: it must also be defined on the basis of results. These results have consisted in the historical fact of a succession of dominant groups. And the chief characteristics which analysis reveals as having contributed to the rise of these groups are improvements that are not one-sided but all-round and basic, such as temperature-regulation or placental reproduction.

It might be held that biological inventions such as the lung and shelled egg, which opened the world of land to the vertebrates, are after all nothing but specialisations. Are they not of the same nature

as the wing, which unlocked the kingdom of the air to the birds? This is in one sense true; but in another it is untrue. The birds, although they did conquer a new section of the environment, in so doing were as a matter of actual fact cut off from further progress. Theirs was only a specialisation. The conquest of the land, however, not only did not involve any such limitations, but made demands upon the organism which could be and in some groups were met by further changes of a definitely progressive nature. Temperature-regulation, for instance, could never have arisen through natural selection except in an environment with rapidly changing temperature.

As revealed in the succession of steps that led to new dominant forms, progress has taken diverse forms: at one stage, the combination of cells to form a multicellular individual, at another the evolution of a head; later the development of lungs, still later of warm blood, and finally the enhancement of intelligence by speech. But all have, though in curiously different ways, increased the organism's capacities for control and for independence; and each has justified itself not only in immediate results but in the later steps which it made possible.

So much for the fact of progress. What of its mechanism? It will be clear that if natural selection can account for adaptation and for long-range trends of specialisation, it can account for biological progress too; for progressive changes have obviously given their owners advantages. Sometimes it needed a climatic revolution to give the progressive change full play, as at the end of the Cretaceous with the mammal-reptile differential of advantage: but when it came, the advantage had very large results—wholesale extinction on the one hand, wholesale radiation of new types on the other. It seems to be a general characteristic of evolution that in each epoch a minority of stocks give rise to the majority in the next phase, while, conversely, of the rest the majority become extinguished or are reduced in numbers.

There is no more need to postulate an *élan vital* or a guiding purpose to account for evolutionary progress than to account for any other feature of evolution.

One point is of importance. Although we can quite correctly speak of evolutionary progress as a biological fact, this progress is of a particular and limited nature. It is an empirical fact that evolutionary progress can only be measured by the upper level reached; for the lower levels are also retained. It is of course a fallacy to use this fact as an argument against the existence of progress. To do so is on a par with saying that the invention of the automobile does not represent an advance, because horse-drawn vehicles remain more convenient for certain purposes, or pack animals for certain localities.

One somewhat curious fact emerges from a survey of evolutionary progress. It could apparently have pursued no other course than that which it has historically followed.

Multicellular organisation, triploblastic development, a cœlom and a blood system were clearly necessary to achieve a reasonable level of size and organisation. Among the cœlomates, only the vertebrates were eligible, for only they were able to achieve the combination of active efficiency, size, and terrestrial existence needed as a basis for the later stages of progress. The arthropods are not only hampered by their moulting, but their land



forms are restricted by their tracheal respiration to very small size and therefore to cold-bloodedness and to a reliance on instinctive behaviour. Thus lungs were one needful precursor of intelligence.

Warm blood was another, since only with a constant internal environment could the brain achieve stability and regularity for its finer functions. This limits us to birds and mammals. Birds were ruled out by their depriving themselves of possible hands in favour of actual wings.

Remain the mammals. Most mammalian lines cut themselves off from ultimate progress by concentrating on immediate specialisation of limbs, teeth, and sense of smell. As Elliot Smith has set forth, the penultimate steps in human development could never have been taken except in the trees, where the forelimb could be converted into a hand, and sight inevitably ousted smell as the dominant sense. But for the ultimate step it was necessary for the anthropoid to descend from the trees before he could become man. This meant the final liberation of the hand, and placed a higher premium upon intelligence. Further, the fœtalisation necessary for a prolonged period of learning could only have occurred in a monotocous species.

The final step taken in evolutionary progress to date is that to conceptual thought. We see, however, that this could only arise in a monotocous mammal of terrestrial habit, but arboreal for most of its mammalian ancestry. All other known groups of animals are ruled out. Conceptual thought is not merely found exclusively in man: it could not have been evolved on earth except in man.

Evolution is thus seen as a series of blind alleys. Some are extremely short—those leading to new genera and species that either remain stable or become extinct. Others are longer—the lines of adaptive radiation which run for tens of millions of years before coming up against their terminal blank wall. Others are still longer—the lines that have led to the development and advance of the major phyla; their course is to be reckoned in hundreds of millions of years. But all save one have terminated blindly.

Only along one single line is progress and its future possibility being continued—the line of man. If man were wiped out, it is in the highest degree improbable that the step to conceptual thought would again be taken, even by his nearest relatives. In the ten or twenty million years since his ancestral stock branched off, these relatives have been forced into their own lines of specialisation, and have quite left behind them that more generalised stage from which a conscious thinking creature could naturally develop.

#### THE EVOLUTIONARY FUTURE.

What of the future? In the past, every major step in evolutionary progress has been followed by an outburst of change, whether by exploiting anew the familiar possibilities of adaptive radiation, or by peopling new environmental realms, or by improving the fundamental progressive mechanism itself.

Conscious and conceptual thought is the latest step in life's progress. It is, in the perspective of evolution, a very recent one. Its main effects are indubitably still to come. What will they be? Prophetic phantasy is a dangerous pastime. But at least we can exclude certain possibilities.



Man is not destined to break up into separate radiating lines. For the first time in evolution, a new major step in biological progress will produce but a single species. We can also set obvious limits to the extension of his range. Thus the main part of any large change in the biologically near future must be sought in the improvement of the brain.

First let us remind ourselves that with our human type of society we must give up any hope of developing such altruistic instincts as the social insects. It would be more correct to say that this is impossible so long as our species continues in its present reproductive habits. If we were to adopt some system for using the gametes of a few highly endowed individuals, directly or from tissue-cultures, to produce all the next generation, then all kinds of new possibilities would emerge. Man might develop castes, and some at least of them might be endowed with altruistic and communal impulses.

Meanwhile there are many obvious ways in which the brain's level of performance could be raised. If for all the main attributes of mind the average of a population could be raised to the level now attained by the best endowed ten-thousandth or even thousandth, that alone would be of far-reaching evolutionary significance. Nor is there any reason to suppose that such quantitative increase could not be pushed beyond its present upper limits.

Further, there are other faculties, the bare existence of which is as yet scarcely established: and these too might be developed until they were as commonly distributed as, say, musical or mathematical gifts are to-day. I refer to telepathy and other extra-sensory activities of mind, which the work of Rhine, Salter and others is now forcing into scientific recognition.

In any case, one important point should be borne in mind. After most of the major progressive steps taken by life in the past, the progressive stock has found itself handicapped by characteristics developed in earlier phases, and has been forced to modify or abandon these to realise the full possibilities of the new phase. This evolutionary fact is perhaps most obvious in relation to the vertebrates' emergence from water on to land; but it applies in other cases too.

Man's step to conscious thought is perhaps more radical in this respect than any other. By means of this new gift, man has discovered how to grow food instead of hunting it, and to substitute extraneous sources of power for that derived from his own muscles. And for the satisfaction of a few instincts he has been able to substitute new and more complex satisfactions, in the realm of morality, pure intellect, æsthetics, and creative activity.

The problem immediately poses itself whether man's muscular power and urges to hunting prowess may not often be a handicap to his new mode of control over environment, and whether some of his inherited impulses and his simpler irrational satisfactions may not stand in the way of higher values and fuller enjoyment. The poet spoke of letting ape and tiger die. To this pair the cynic later added the donkey, as more pervasive and in the long run more dangerous. The evolutionary biologist is tempted to ask whether the aim should not be to let the mammal die within us, so as the more effectually to permit the man to live.

Man seems generally anxious to discover some extraneous purpose to which humanity may conform. Some find such a purpose in evolution.

The history of life, they say, manifests guidance on the part of some external power ; and the usual deduction is that we can safely trust that same power for further guidance in the future.

I believe this reasoning to be wholly false. Any purpose we find manifested in evolution is only an apparent purpose. It is we who have read purpose into evolution, as earlier men projected will and emotion into inorganic phenomena like storm or earthquake. If we wish to work towards a purpose for the future of man, we must formulate that purpose ourselves. Purposes in life are made, not found.

But if we cannot discover a purpose in evolution, we can at least discern a direction—the line of evolutionary progress. And this past direction can serve as a guide in formulating our purpose for the future.

As further advice to be gleaned from evolution there is the fact that each major step in progress necessitates scrapping some of the achievements of previous advances. But this warning remains as general as the positive guidance. The precise formulation of human purpose cannot be decided on the basis of the past. Each step in evolutionary progress has brought new problems, which have had to be solved on their own merits ; and with the new predominance of mind that has come with man, life finds its new problems even more unfamiliar than usual.

The future of man, if it is to be progress and not merely a standstill or a degeneration, must be guided by a deliberate purpose. And this human purpose can only be formulated in terms of the new attributes achieved by life in becoming human. Human purpose and the progress based upon it must accordingly be formulated in terms of human values ; but it must also take account of human needs and limitations, whether these be of a biological order, such as our mode of reproduction, or of a human order, such as our inevitable subjection to emotional conflict.

Obviously the formulation of an agreed purpose for man as a whole will not be easy. There have been many attempts already. To-day we are experiencing the struggle between two opposed ideals—that of the subordination of the individual to the community, and that of his intrinsic superiority. Another struggle still in progress is between the idea of a purpose directed to a future life and one directed to this existing world. Until such major conflicts are resolved, humanity can have no single major purpose, and progress can be but fitful and slow.

But let us not forget that progress can be achieved. After the disillusionment of the early twentieth century it has become as fashionable to deny the existence of progress, and to brand the idea of it as a human illusion, as it was fashionable in the optimism of the nineteenth century to proclaim not only its existence but its inevitability. The truth is between the two extremes. Progress is a major fact of past evolution ; but it is limited to a few selected stocks. It may continue in the future, but it is not inevitable ; man must work and plan if he is to achieve further progress for himself and so for life.

Our optimism may well be tempered by reflection on the difficulties to be overcome. None the less, the demonstration of the existence of a general trend which can legitimately be called progress, and the definition of its limitations, is a fundamental contribution to thought ; and we zoologists may be proud that it has been made, chiefly from the zoological side, by evolutionary biology.

## SECTION E.—GEOGRAPHY.

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# MAPPING OF THE COLONIAL EMPIRE

ADDRESS BY

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PRESIDENT OF THE SECTION

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It seems ridiculous, from this chair, to begin with cycles and waves. Yet I feel compelled to do so. We, as geographers, owe our own progress very largely to the innumerable impulses recorded by the advances of other sciences, and of other branches of knowledge. Their wave-lengths of progress—their cycles of advance and research—may be different from ours, but none the less geography is, at once, their debtor and their catalyst. Our environment is both physical and human. Our analysis and our correlations are at fault if we do not study and profit from any advance in the knowledge of environment, and man's reaction to it. No new find at Babylon or in the Tombs of the Kings but adds to our bill of fare. We wait upon the explanation of climatic changes in Greenland as eagerly as does Geodesist or Geologist, and we find trade cycles as important as those of sunspots. It is a fact that the study of man's reaction to his environment is so wide that we must draw our raw material from all sides and from all authorities. Our progress is, in large measure, dictated by theirs.

In one important particular, however, geography, in the original sense of that difficult word, provides its own raw material. To take proper stock of our world we must map it. A globe, a map, a plan, a chart—these are not only records of our physical environment, but provide the background against which all other factors may be shown. My distinguished predecessor in this chair, pointing out that most of us are still immobile in this world of ours, said that we still have to take our impressions of regions other than our own from picture or narrative. No doubt that is true. We may get an impression of the Highlands of Scotland from Sir Walter Scott's *Waverley* amplified by the attractive advertisements of sundry hydropathics.

But if we want the facts we turn to the 1-inch map, the geological map, the agricultural atlas and the population map. Later on, in his interesting



survey of the polar regions, Prof. Debenham gets drawn into maps as naturally as every geographer is bound to be. He complains of projection difficulties, foresees a 'germ-density' map, and fears that the political maps may become too highly coloured. Indeed no one could expect a representative of that ancient seat of learning to do anything else than face the facts of life. It would be a waste of time to beat about the bush. Maps are potted information about environment, and about man. They are indispensable to us and, at the moment, we are, as regards their production, in the trough and not on the crest. We are living through a cycle of indifference and we are forgetting the lessons of history. That is the reason, as you all know, why one who has no claims to geographical eminence speaks to you to-day. It is because the illustrator is of significance even if he pales before the author. The mapping cycle is of as much, if not more, importance than any other.

The bald statement that we are in the trough of the wave may take many by surprise. For over a century we have had reason to be proud of the mapping of the British Isles. For much of that period we have known ourselves to be the best mapped country in the world. The survey of India has had an extraordinary fine record, and for a period of twenty years or so we tackled the mapping of Africa, largely to illustrate its partition, with zeal. Then came the war, and, since that time, whether in the short boom or in the long depression, survey departments have shared in a neglect similar to that of the fighting services. In England itself the reason for this neglect is curiously difficult to find. Our maps and plans might serve a military purpose just as a London omnibus, or a screw factory, might. Their primary purposes are to help the work and the play of the nation as a whole. For example, no revision of the plans shows the railway system of the Kentish coal-fields, or records the growth of Scunthorpe, and so, up and down the land, innumerable interests have had to map themselves and pay double for it. No revision of the maps is complete in showing the full effects of the road programme.

To get closer to geographical matters; on what maps may we study the growth of industrialism in the south, or where shall we look for a record of the expansion of Birmingham? What 6-in. plans of the Highlands will explain in detail the water power schemes of to-day? What is Kinlochleven like now?

A distinguished American—President of the International Union of Geodesy and Geophysics—remarks that the principal reason for the very backward state of the mapping of the United States lies in the fact that that country has been rich enough to survive the handicap of inadequate mapping. Are we rich enough to survive the handicap of losing the value of our original survey? and to pay through the nose for overlapping work on the rates? In 1922 we had both to live frugally and to build a 'land for heroes.' On the one hand we began ambitious building programmes and started to recast our road communications, whilst on the other we cut the survey votes to the bone. Building means supply services and drainage, and we had, before us, the warnings of the cholera epidemic of 1841 with its enforced and overlate expenditure on town plans.

Roads mean adjustments of property and administration and we had the warnings of the waste of two millions on the poor and local surveys of the tithe maps; and the demands of legal and administration authorities which doubled the survey of 1880. It is as if an elderly gentleman, overstout for his shabby suit, reluctantly ordered another from his tailor with strict injunctions to use a yard less material. In this particular, the revision of ordnance maps and plans of Great Britain, things look like improving. The Ordnance Survey, tucked away in that onetime asylum in Southampton, keeps on doing its best, and its difficulties are, at last, being considered. None the less all British geographers have a duty in this matter. We ought to see that our house is kept in order, and that the staff of the Ordnance Survey is not halved just when the changes of development are doubled.

We must have the maps, indeed, not only for what they show, but for what they can be made to show. Against the black background of map detail any subject can be illustrated in colour. There is no need to talk distribution maps to an audience of geographers, yet it is astonishing how little has been done. Geology was the first science to map itself, and the Ordnance Survey has done much for the mapping of archaeology and history. Within limits it is perhaps easiest for that department to provide the appropriate and contemporary outline. A population map, perhaps only in tentative form, illustrates the 1931 census. It seems to me important that distribution maps for subjects of first-rate national importance should be made and revised at stated intervals so that, in the future, comparisons may be based on unimpeachable evidence, and tendencies identified and studied. Intensive studies of small areas are the realm of geographers themselves. They can be well illustrated in black and white, and the records will be found in geographical magazines. But there is always need of a more general and wider stretching picture. It is not a necessity that every geographer should be word perfect on land utilisation in Glen Clova, but it is a necessity that he should be well aware of the differences of population density in Great Britain. Here we come back to a national field, and one into which we are just entering.

It may be of interest to see what the national survey has done in the question by recording the genesis of some of our editions. In the first instance the Geological Survey started as the 'Ordnance Geological Survey.' The 10-mile map began as a map for the River Commissioners. The  $\frac{1}{4}$ -inch map was first produced at a joint call of archaeologists, geologists and soldiers, the 1/M to answer a request from an international assembly of geographers. Physical editions at various scales have been made at the request of British geographers. Population maps were made to help in the delimitation of interstate boundaries, and, at the special request of this section, to illustrate the 1931 census. Archaeological and historical maps are a case of spontaneous combustion, and are, as a matter of fact, a by-product of the mapping of the relevant sites, which is a normal function of the Ordnance Survey.

On the whole, in Great Britain, the situation is none so bad as far as the geographer is concerned. Municipal administration, town and regional



planning, land transactions, and comfort of motor travel, have suffered more than geographical analysis. It is a very different story if we turn to the vast areas under the British flag overseas. Here I am not going to talk of the Dominions, for they are masters of their own affairs. It is enough perhaps to suggest that they, too, are wealthy enough to survive the handicap of inadequate mapping. The Anglo-Saxon abroad does not seem to start with any very definite convictions on the question of good stocktaking. Let us turn to the areas under the Colonial Office. The first, best, and to us most natural, preliminary is to see what our forbears did, and thought, about it, so that we may avoid the pitfalls they fell into and start where they left off.

At the close of the eighteenth century, Major-General Roy, Surveyor-General of the Coasts, Fellow of the Royal Society, Mapper of the Highlands, and spiritual father of the Ordnance Survey, had died. The connection between the Observatories of Greenwich and Paris had been established by triangulation. The Master-General of the Ordnance had appointed a small staff, and set about the mapping of the British Isles, and the question arose, 'What about the Colonies? What about maps of foreign parts?' The Ordnance Survey was domestic. We wanted something at once imperial and diplomatic.

The first step taken was to install, in 1803, the 'Depôt of Military Knowledge,' a branch of the Quarter-Master-General's Department, and it included a 'drawing room' for the copying and storing of maps and plans. It is comforting to note that it was to be watched over by 'an officer of approved knowledge,' and that one of the clerks 'conversant with foreign tongues' was to receive 7s. 6d. a day.

Thereafter Napoleon was finally vanquished; these tiresome new ideas ceased to worry us for a time; and a minor boom and a major depression came as usual to rub in the consequences of war. The Depôt of Military Knowledge experienced, in that post-war period, what the Ordinary Survey suffered in a later one, and it was not until the Crimean War that the matter was revived.

Major Jervis, a retired Sapper, had been employed on survey work in India. He had refused, unbelievably enough, the appointment of Surveyor-General in India, but he had tasted the joys of map-making and knew what he was talking about. In 1846 he wrote to the then Foreign Secretary, Lord Aberdeen, as follows:

'Great Britain is the only country of note which has no geographer attached to the Government, and no national depôt of geographical maps and plans. The Ordnance Survey is exclusively directed to British territories' (he meant the British Isles); 'the Hydrographic Office to nautical charts'—and so on to the wisdom of equipping the Foreign Office, in particular, with reliable maps on which to study the problems of territorial diplomacy. I ask you to note the underlying idea. Because it was suggested by a soldier it would be assumed, to-day, that it was aimed at destruction, and meant to be conducted in the darkest secrecy. No such thing. The idea was a national office for the production of oversea maps required by government departments.



The next stage is pure farce. The idea was good but nothing was done. The Crimean War was casting its shadow ahead, and Major Jervis, in a foreign capital, copies Russian and Austrian staff maps of the relevant areas. The war duly breaks out. Major Jervis reappears with the most priceless maps. He is told that there is no precedent for supplying soldiers gratis with maps, but that some will, no doubt, be bought, if he makes them himself. One can almost see the peremptory hall porter asking to see his pass as he left the War Office of the day. But, stout fellow that he was, he accepted the challenge. Making his own map office he printed his maps which were, of course, invaluable.

By 1855 this new idea had had time to become respectable. The 'Topographical and Statistical Department' was formed, and Jervis, reminded of his 'varied attainments,' and of the 'great attention' he had paid to 'geographical Science' was offered the command, together with a coach-house and stables in Whitehall in which to start his dark and hidden calling.

Let us examine his own draft for his terms of reference.

'1. Compilation and printing of all maps required for military and political purposes. Collection of maps published at home and abroad, and of topographical and statistical information about the colonies and foreign countries.'

Note again—'political' and 'Colonies.'

In 1857 Colonel Jervis, as significant a figure in British topography, as perhaps, General Roy, was gathered to his fathers, and we find Lord Panmure, 'Secretary at War,' calling a committee to consider what had been done, and what should follow.

The committee recommended that the department should be an independent branch of the War Office empowered to employ officers and men from any branch of the British and Indian armies or from civil life, and that it should aim at 'procuring topographical information.' Lord Panmure's instructions are even more significant.

'Lord Panmure is desirous that you direct an early attention to the subject of Colonial surveys, ascertaining as far as possible what works of this nature are in progress at the expense of Colonial legislatures, and reporting whether it may not be possible to establish a system, under which your department, with the concurrence of the Secretary of State for the Colonies may assist in their systematic prosecution, His Lordship being satisfied that whether from a military, scientific, or a national point of view, it is of much importance to bring all the topographical operations of the British Colonies into harmony with one another, and to collect all information respecting them at a central establishment accessible to government.'

For some years this 'Topographical Department' and the Ordnance Survey were coalesced under the direction of General Sir Henry James. Then the 1-in. of Great Britain was finished, the large scale survey (10 ft., 5 ft., and 25-in. to the mile) began, and War Office votes could not be stretched, it was thought, so far. The departments fell asunder

again: the Ordnance Survey to be the national and domestic map maker. the 'Topographical Department' to be the national and overseas (but predominantly colonial) mapmaker. Both, however, were the suppliers and advisers for all departments of state.

Is it in any way curious that the War Office should father a national institution of this sort? Is it curious that Astronomers Royal should shelter under the wings of their Lordships of the Admiralty, or that the Meteorological Office should flourish under the Air Ministry? Should they all be under a 'Ministry of Applied Science'? But it is the privilege of the 'Golden Bough' to wander, delightfully from point to point, and I must back to mapping.

The Topographical Department continued to grow and to subdivide. It gave birth to 'Military Intelligence' and to 'Military Operations.' As so often happens the sons overtopped the father. The department was, for a time, under the hand of the late Lord Cromer, it has been the nursery for many distinguished soldier surveyors, and we bring it up to the time of the Boer War with a brief reference to the two germs from which, in spite of all its good work, it did suffer. These are:—

- (a) The germ of anaemia, due to starvation when no peril threatened.
- (b) The germ of hypertrophy, due to taking too seriously the minor lessons of the last war (whichever it was).

At the beginning of this century the department was, as for some time it had been, the institution which provided the trained officers and men for boundary commissions and topographical surveys abroad; which had the best map library in the country; which provided topographical maps and advice to all departments of state, and which was closely in touch with the Colonial Office on matters pertaining to the Colonial Survey departments.

The Topographical Department was now rechristened the Geographical Section of the General Staff (or M.I. 4 for short), and it is time to consider its work under two the normal subheads:

- (a) The compilation and publication of maps of unsurveyed, or only partially surveyed, areas.
- (b) The actual survey on the ground—the real mapping—of the Colonies.

For making the best possible use of all knowledge preceding survey—the routes of travellers, the occasional observed latitude and longitude, the rare railway or river plan, and the still rarer record of local surveying—the Geographical Section acquired a staff of draughtsmen probably unequalled in Great Britain. The first maps of Africa made by the Section were the 1/M and the 1/250000 series. These were compiled from all sorts of information, included many inaccuracies, but for some ten years were by far the best maps of the continent. Another large and important series was the 1/250000 of Asia Minor, which was still the best map of those parts when the war broke out. With a prescience which



became proverbial the Section also mapped the Sinai Peninsula, and South Palestine, and with that geographical instinct characteristic of its then Chief, Sir Charles Close, put the international 1/M on a firm basis. We should notice, in passing, the significance of the 1/250000 scale so much used in these early maps. If we take the  $\frac{1}{4}$ -in. as being practically identical with it, and compare the areas of the world mapped at those three alternative small scales 1/250000, 1/200000, and 1/300000 we find that they are in the proportions 13, 3 and 1.

Since the war those two great series—the 1/4M of Asia and the 1/2M of Africa—have proved enormously useful, and it is right to mention them in passing, because it is just for such painstaking reliable maps as these that we look to the Geographical Section. I have no doubt at all that the best maps of Abyssinia to-day are the sheets on both these series (which overlap in Arabia Felix and Abyssinia), and that they are the basis of all other maps, recently published, of that country. Here is one part of the original terms of reference well kept up.

But to-day I want to speak of the other side—item (b) reliable survey on the ground. In the first years of colonial expansion a general map compiled from odd routes and sketches may suffice. Even so administration finds all sorts of difficulties. One is, everywhere, dependent on a guide. There is no stocktaking of the country and its peoples. There is no guide to tribal and trade movements, to the grazing grounds of the different seasons, the limits of this or that local custom, or the places where conflicting interests may result in friction. Then come the problems of development. Where shall the railway run (we are nearly always caught napping over that); how shall the road system develop; where are the raw materials (of which we hear so much to-day). It is absurd to try to solve all these by trial and error. And finally there are many vitally interested people at home, such for example as ourselves, who can form no accurate mental picture without a map to work on.

The first land surveyors to begin work in the Colonies were not, however, always, or necessarily, directed by the Geographical Section. All over the world, and from the earliest times, you will find that surveying originates in two distinct ways, serves two separate purposes, works at different scales, and survives almost everywhere, save in Great Britain, in the form of overlapping survey departments to-day. The one is the property survey which safeguards property rights and forms the basis of land taxation, and the other the topographical survey, usually based on triangulation, which is the national stocktaking. The former is generally, or was generally, carried out by a private practitioner for a client; the latter by state surveyors normally soldiers. The former is always measuring lengths, the latter usually angles; the former is not concerned with altitudes, the latter finds much of his work in contouring. In colonial expansion both these sides are required, but whereas the necessity for the property surveyor is immediately obvious, the greater significance of the topographer, promising rewards of the future rather than of the present, is generally overlooked.

Since, however, the property surveyor comes first in time (he was



active in Sumeria) we will take him first in Africa. He dates back, here, to the earliest days of Dutch settlement at the Cape. Naturally in the busy times of the great trek his work was of the sketchiest. He improved with the times and with competition. He became subject to certain State inspections; presently he had to show certain diplomas; he turned into the 'licensed surveyor.' In his native land (the Dominion of S. Africa) he has never made a map, but he has first-rate education in instrumental surveying and can deal readily enough with a least square adjustment. Then presently the Rhodesias, British East Africa, and the West Coast colonies began to call for his like, and he came. With him came others trained in similar schools for similar work from Australia, Canada, and New Zealand, but, with very rare exceptions, never from England. Here, at home, large scale surveying had been taken over by the State, and the profession was extinct. Thus were born the Colonial Survey Departments of Africa, just as they had been in earlier times in Ceylon and Bermuda, in Jamaica and Mauritius, in British Guiana and Hong Kong, although in these surveyors from England took more part.

Fortunately for colonial expansion, there have been, generally, Royal Engineers somewhere handy. To them we owe the first roads, railways, cathedrals, government houses, town-planning, canals, and, of course, maps. It was part of our policy in former years that there should be, always, a large number of these Royal Engineer officers on survey work, and every ex-Director-General of the Ordnance Survey still surviving found his topographical training at that duty. In a small part of Hampshire within a circle of some eight miles radius live the three who had most to do with framing our very successful war surveys. Between them, in their earlier years, they surveyed in almost every part of Africa. Such Royal Engineer officers, sometimes on the Colonial pay-roll, sometimes on that of the War Office, sometimes drawing partly from both, but always chosen and directed (even if indirectly) by the Geographical Section, began the topographical mapping of Africa.

A third element appears, however, before the fusion of property and topographical surveying. In Great Britain the Ordnance Survey was always greatly helped by the Astronomers Royal. Airy, for example, was one who was closely in touch with its development. The Astronomer Royal in Cape Town early in this century was Sir David Gill, and it was due to his energy and persistence that the geodetic triangulation of South Africa was undertaken and completed. His great ambition was to see it carried on through the heart of Africa till, joining up with the Egyptian triangulation, it should form a continuous arc, roughly along the meridian of  $30^{\circ}$  E. of Greenwich. It is noteworthy that most of the officers concerned in the measurement were Royal Engineer officers lent by the War Office. The great arc will appear again and again in considering the recorded geography of Africa because its prosecution and completion are entirely vital to any reasonable survey of East Africa. As we all know the Isle of Wight could be mapped on a basis of a little plane trigonometry, but Great Britain required a primary triangulation. We never boggled at the triangulation inevitable for India, and yet with all this African

territory to administer and improve we cannot find it possible to finish even the first and most vital preliminary.

Let us return for a moment to what one may describe as imperial surveying, under the immediate leadership of the Geographical Section. Early in the century a 'Colonial Survey Section' was formed. Its object was topographical mapping with the theodolite and plane-table, and its subject the Colonies. Starting with Mauritius and St. Helena, hitherto charted but unmapped, we find it at work in the then Orange River Colony from 1905 to 1911. The result of that survey is a reliable  $\frac{1}{2}$ -in. map. A large part of Northern Cape Colony was mapped on the  $\frac{1}{4}$ -in. scale, as was Basutoland, by officers individually selected by the Geographical Section. The Colony (or peninsula) of Sierra Leone, Pemba Island, and many parts of the Transvaal were also mapped before 1912. A reconnaissance survey of Northern Nigeria was finished in the same imperial fashion, whilst substantial portions of Asia were tackled in the same way.

More significant still, however, were the geographical results of boundary Commissions. It is the British practice, or was until quite recently, not only to see that the boundary is correctly placed on the earth's surface, but to map a strip of territory on each side, in order to facilitate a decision, if there is disagreement, to examine thoroughly the resources and lie of the land through which the dividing line is to run, and to make it easy to find and to restore the boundary marks. From 1900 to 1913 no less than 10,000 miles of African boundary line were placed on the ground, by astronomical observation and by triangulation, permanently marked, and mapped to some considerable depth on either side. Some of these surveys were connected to Gill's arc, which by 1913 had reached the southern end of Lake Tanganyika (a distance of 1900 miles). Most, however, were based on independent datum points, and remain to be incorporated, one day, in a general triangulation.

We may say, at this moment, that most of the mapping of Africa under the British flag is hung upon and controlled by Gill's arc, or the boundary commission triangulations.

Now turning again to the Colonial Survey Departments we come to the birth of the 'Colonial Survey Committee.' Its formation was inspired by Colonel Sir Charles Close, who was, at that time, the chief of the Geographical Section. Its object was to strengthen that vital element in the terms of reference of the section 'to assist in the systematic prosecution . . . of topographical operations of the British Colonies . . . with the concurrence of the Secretary of State for the Colonies.'

The Committee began its labours with Ceylon. It insisted upon and secured a topographical survey long overdue. In Africa it began to realise that fusion between property and topographical surveying is essential if these departments are to follow the British model of making but the one general survey of the country and of avoiding overlap of responsibility.

The first stage in this matter is to provide a triangulation upon which all survey may rest. An indefeasible title to land and title requires it just as much as a general map. The idiotic waste of money implied in per-



petual measurements along the ground, and in a fresh azimuth for every field or homestead; that overlapping effort which, in Great Britain 'fell as a heavy burden upon the whole community' before the days of the Ordnance Survey, had to be eliminated. There seems to be something fatally soporific about a general truth to which everybody can assent in principle, but in respect of which no one feels compelled to get busy at once. How many political illustrations have we not had lately of this curious fact! It will be best to give a concrete illustration of what triangulation does do. In Northern Nigeria lies that Bauchi Plateau inhabited by pagans and tin-miners, which has seen so much alienation of land for mining concessions, and from which so much of the world's tin has come. Very early in the development of Northern Nigeria it became a problem how to keep pace with applications. A party of Royal Engineer officers and men was called for. A hasty triangulation was made and the arrears were caught up with. But then came the war. The party was recalled. The officer who had made, and computed, the triangulation was killed, and his records were lost in the confusion of the times. After the war the rush started again. Applications were now dealt with in the ancestral fashion of property surveying. Each concession was a problem all of its own. Measures were duplicated, and arrears began to mount up. At last another imperial party was borrowed. A good and permanently marked triangulation was extended from the growing primary triangulation of the colony. Arrears were promptly overtaken, and now each fresh concession can be surveyed at quarter the time and cost.

In pursuance of the policy of amalgamating the two sides of survey the War Office, which, in 1913, had 100 Royal Engineer officers on survey duty, lent many officers and men to the Colonial Survey Departments. In West Africa activity was general. In Kenya and Uganda a really good triangulation was extended from the Boundary Chains, and a great deal of really sound mapping was finished at 1-in. and  $\frac{1}{4}$ -in. scales. In some cases the Colonial Survey Department was put under a Royal Engineer, in others imperial parties were lent to the Surveyor-General to get on with the mapping and triangulation. Whilst these activities were in progress an imperial party, fresh from the boundary between Uganda and the Belgian Congo, started to measure a portion of Gill's arc along the 30th meridian in Uganda. Finally a complete tour of inspection was carried out by the late General Hills, visiting each survey in turn, and bringing coherence into the aims, and methods, of the various departments.

Having now considered a period of thirteen years (1900-1913) it will be as well to recapitulate the achievements.

#### PERIOD 1900-1913 (AFRICA ONLY).

##### 1. *Triangulation* (or astronomical or traverse control).

(a) The completion of the geodetic survey of South Africa.



- (b) The arc of meridian  $30^{\circ}$  E. of Greenwich :  
 1900 miles, Port Elizabeth to Lake Tanganyika.  
 150 miles in Uganda.
- (c) Boundary Commissions, 10,000 miles.

## 2. *Reliable mapping.*

Boundary Commission maps, topographical surveys of parts of the Gold Coast, Nigeria, Sierra Leone, Cape Colony, Kenya, Uganda, Transvaal, and the whole of the Orange Free State and Basutoland, and subsequent publication on the 1 in.,  $\frac{1}{2}$ -in. and  $\frac{1}{4}$ -in. scales. Total Area 330,000 square miles.

## 3. *Compilation Maps.*

The 1/M, and 1/250000 series of all Africa then under the British flag.

## 4. *Administrative.*

Formation of Colonial Survey Committee. The building up of Colonial Survey Departments. The first general inspection.

The war period brought the mapping and revision of Great Britain to a full stop. In Africa it did not have quite the same effect. We learnt, of dire necessity, a good deal about East Africa, and improved the compilation of the more generalised maps. A more important consequence was the unfortunate renewal of the divorce between the topographical and property surveying sides. Royal Engineers were either recalled or employed on other duties. The survey of Kenya, for example, has never recovered its pre-war usefulness, and even the maps of that delightful land, made before the war, lie neglected and now out of date. This department—too small in strength to undertake triangulation or mapping—has reverted wholly to the cadastral. There is a bright spot to notice about the war. On many a battlefield the regular and the temporary, the topographical and the property surveyor, met and learnt, often in the Field Survey Battalions, each other's methods and technique. There is going to be small difficulty in broadening out when administration learns that maps are as indispensable to a knowledge of human factors as to the development and exploitation of natural resources.

In considering what has been done since the war, why it is so little, and what can be done to augment it, we can take the period of thirteen years, from 1922 to 1935, and so achieve a direct comparison with the former period of 1900 to 1913. But, alas! there is little good to record.

Let us consider first the framework—the geodesy; for land surveying, to be consistent and continuous, must be held together by a rigid framework. Mudge in England, Everest in India, made no mistake in their beginnings. First a triangulation to hold together the areas of their task, and then

topography. They worked from the whole to the part. In that contiguous and vast country from the Limpopo to the Egyptian border we must equally work from the whole to the part, unless, in the future we are content to scrap this or adjust that. At present we are working from five parts. This it was that Sir David Gill hoped to avoid. His great and controlling arc coming up from the south is like a steel rod with one fixed, and one vibrating, end. A section lies nearly in place ready to be bolted on. A long stretch remains open, and the clamp at the northern end waits on the final connection. From 1900 to 1913 2050 miles were measured; from 1922 to 1935 only 360! During my tour of inspection in Africa (next in sequence after that of General Hills) this enterprise got to be derisively known as the 'arc of the covenant.' It was indeed difficult to explain its fundamental importance to minds more apt with the Humanities. Yet something—if only 360 miles—came of my strivings: a really absurd contribution to a subject which affects every geographical position from Capetown to Cairo.

On the west coast much more of this fundamental programme has been tackled. There had been much activity in triangulation there before the war, and after it Sir Gordon Guggisberg, first as Surveyor-General and then as Governor of the Gold Coast, kept up a well-organised programme. In these later days the Surveyors-General of Nigeria and the Gold Coast have greatly enlarged and strengthened his earlier work. It is true that on the Eastern Plateau some triangulation has been done. The surveyors themselves have done their best, but in doing so are aware that all their present triangulations must some day be corrected and that the longer it is put off the greater will be the burden and cost of adjustment.

The next point of importance is to build, as have Great Britain and India, departments economical in production and graded into specialised groups. It might be very amusing to build the whole of a motor car with one's own fingers, but it would be singularly uneconomical. The first Colonial Survey Department to appear in order to make settlement, and alienation of land, possible, is composed, as stated before, of the property or cadastral element. It is staffed by men who are trained to carry out, with their own hands, any and every type of instrumental measurement of land, and thereafter to provide a finished drawing. The field books containing their measurements are the records, and the justification, for their finished work. Could India have ever been surveyed by a collection of individualists each doing everything in turn? All big survey departments rest indeed upon a staff designed for mass production. The trigonometrical observer is not his own computer; the detail surveyor is not the draughtsman; and no one of the four attempts lithography. For the mapping of Africa this is a vital point. Methods and processes must be simplified and divided up until the staff can be doubled without increase of cost. In 1907 General Hills pointed this out, during his tour of inspection, and on the west coast General Sir Gordon Guggisberg, began to raise a corps of native surveyors.

These native surveyors have done well because the methods in which



they have been trained are simple and undeviating. It is curious to note that they are very much those of Roy and Mudge. During the first (and indeed only) topographical surveys of Great Britain (since 1855 all the maps of Great Britain have been made by direct reduction from the plans) the compass and chain were used instead of the plane-table, because the use of the latter demands a visibility rare in this country. It is equally rare in the forest belt of West Africa. Kitchener was ill-advised to introduce these traverse methods into Cyprus and Palestine, but Guggisberg made no mistake in basing his west coast surveys upon them. A remarkable instance of what can be done in this way is offered by Sierra Leone where the whole of the hinterland has been mapped at the 1-in. scale by native surveyors under the supervision of officers of the Royal Engineers. It is an equally striking commentary on our methods that the greater part of this excellent series remains in manuscript, and does not look like publication for many a long day. In the higher and drier plateaux of East Africa the natural implement is the plane-table. So far, however, no topographical native plane-tableers have been trained. I am convinced that they could be raised, trained, and made efficient. It seems to me absurd to maintain that the standard of intelligence is lower amongst the Bantus than among the Negroes. Whenever the question has been discussed, however, it has been assumed that instrumental and mathematical questions are at stake. They are not. Plane-tableing demands qualities of craftsmanship and honesty, but has practically nothing to do with instrumental or mathematical surveying. Presently, no doubt, common sense will have its way. Meanwhile native labour comes in slowly with the beginnings of printing, and gradually the Colonial Surveys of Africa will follow the model of the surveys of India, Ceylon, and Malaya. It is, however, due to the lack of proper organisation that the amount of reliable survey in our second period is not more than a third of that contributed by the first.

It is at this point that the intelligent modern layman begins to talk of air survey. This term was invented for the sake of brevity, and means 'The survey (by any one of a variety of methods) of ground from photographs taken of it from the air.' The photographic image is a perspective view of a solid body (of three dimensions). To extract the plan of two dimensions and to add the third in the form of contours is perfectly possible at a scale not smaller than  $2\frac{1}{2}$  in. to the mile (smaller than that the photograph becomes unreadable). As a method it is invaluable where surveyors cannot get on the ground, and is probably without a rival at such a scale as the 6-in. No one who was able to get to the ground would dream of making a  $\frac{1}{2}$ - or  $\frac{1}{4}$ -in. map of an open plateau in this way because of the expense.

It may be taken as proved that we need not hope for topography from the existing staffs of Colonial Survey Departments. They are not in sufficient numbers, and the value of their education and training implies a salary higher than should be paid for the work.

None of these factors, however, affects the solution employed during our first period, viz. from 1900 to 1913. Then the topographical mapping was



done by parties of Royal Engineers. It could be done equally well in that way now. Why is it not being done? It is not because these African Colonies are 'rich enough to survive the handicap of inadequate mapping,' and it is not because we do not want the invaluable training for those who might have to map in war. It was, indeed, lucky that we had had that training in the pre-war period, for the officers and men so trained quickly raised our war mapping (and kindred matters) to the highest level amongst not unskilful rivals. The War Office has now 30 officers of the Royal Engineers engaged on survey work. This is less than one-third of the pre-war number, and includes just four who are learning, under the proper conditions, how to survey under difficulties. The remainder are busy on the surveys of Great Britain and India in the Geographical Section and in training establishments. Nevertheless the War Office wants the training, the Colonies want the mapping, and Africa is still with us. Incidentally one of the most obvious jobs is to revise the maps made in the pre-war period, and very easy it would be. Let us hope that an equitable bargain may soon be struck!

Although the advantages of a topographical survey are difficult to bring home to the public, and to the administration, both seem content to pay large sums for surveys disguised under other budgets. Almost every colony has authorised special surveys for railways, roads, water projects, draining schemes, and the like. These special surveys would, in large part, be avoided by good mapping, and they are unpublished and play no part in the general development. Yet it is not to be wondered at if we reflect that Great Britain paid two million pounds for a poor collection of tithe maps (also unpublished) rather than begin that large scale ordnance survey, which *had* to be begun shortly afterwards. There is one of our most charming West Indian Islands which insists on remaining unmapped, and which burdens the fruit industry with an annual expenditure of some thousand pounds for its own (unpublished) mapping. In Africa the geologists, I am sure much against their better judgment, are often made to turn themselves into topographers, and are sometimes given trained topographers to supervise. The results of such labours are also unpublished surveys and also a subterfuge for putting off the inevitable. But no doubt geology brings up delicious thoughts of gold or copper, and a booming budget!

Another post-war factor of significance is a change in the practice of boundary demarcation. In many recent instances local officials have been employed, instead of imperial parties. Often when this has been done we have failed to secure the proper mapping of the boundary. The geographical results have fallen off not owing to any lack of ability on the part of the survey staff, but because they cannot supply topographers unless Royal Engineers are attached to the party. Thus, whilst the later period has given us 4,600 miles of boundary determination in Africa, it has given us no more than 3,500 miles of reasonable topography, and that much restricted in depth. Boundary demarcation is one of the finest trainings in quick triangulation and mapping that the world affords. Yet

such men as may be wanted in war have, perforce, been put to train in Hampshire.

We can now summarise the results of our later period, and it will be as well to make a comparative table, and show things for the two periods side by side.

|  | 1900-13.                         | 1922-35.   |
|--|----------------------------------|--|
| <i>Triangulation (or good control) :</i> |                                  |  |
| (a) Geodetic survey . . .                | Geodetic survey of South Africa. | Geodetic survey of Nigeria and part of the Gold Coast. |
| (b) Arc of 30th meridian . .             | 2,050 miles.                     | 360 miles.   |
| (c) Boundary Commission . .              | 10,000 miles.                    | 3,500 miles.   |

#### *Published Topographical Maps*

Resulting from reliable  
survey and including  
boundary commissions  
and local surveys . . .

480,000 sq. miles. 170,000 sq. miles.

*Note.*—During the later period our African responsibilities had grown by no less than 743,000 square miles.

The problem of mapping Africa is not being tackled in fact. Where is the machinery at fault? The Geographical Section has not been idle. It has inaugurated periodical conferences of the survey officers of the empire, and most useful they are. It has started the *Empire Survey Review*, which is, perhaps, the best survey periodical in the world. It inspired the design and manufacture of that best of all theodolites, made by Cook, Troughton & Siemens, and called the 'Tavistock.' It has given ready help on all technical questions. The Colonial Surveyors themselves have realised a complete fusion between the various aspects of their work. Such powder as they have in the magazine is dry. It is the trust in higher beings which has failed.

The fault is that public opinion, with many urgent matters to consider, is as slow to grasp the position in Africa as it was to do so in Great Britain, and there is no force, in being, strong in proportion as the matter is urgent, to call attention to the ultimate economy of starting a definite and progressive programme. In Africa to-day, as in England yesterday, the public suffers because there is no reliable map on which to work. Every private interest and every government department must fend for itself. Lack of maps, or unorganised and piecemeal mapping, amount to the same thing in this particular. They cause a heavy financial burden to fall on the whole community.

There are some generalisations which experience allows us to make. Thus, just as history cannot be divorced from geography, so neither can

social, economic, industrial development be divorced from land surveying. Mapping is indeed one of the vitamins necessary to the growth of the body politic. It is for us geographers to forward this matter. We know that we are failing not only to secure the maps on which we ourselves may study, analyse, and suggest, but we are also failing our friends the geologists, engineers, airmen, settlers, business men, and the people themselves. Never, for a century, have we treated our geographical duties so lightly.



## SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

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# PLANTATION ECONOMY

ADDRESS BY

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PRESIDENT OF THE SECTION.

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### I. THE NATURE OF PLANTATION AGRICULTURE.

THE Royal Commission on Agriculture in India of 1928 in its brief notice of plantations remarks on their importance to the export agriculture of India. 'The three main planters' crops are tea, coffee and rubber, but sugar-cane is important in Bihar as are spices in the South of India. The area under indigo in Bihar, where it was formerly the principal planters' crop, is now negligible. The total area under tea, coffee, rubber and indigo in 1925-26 was 1,169,000 acres, of which 982,000 acres were in British India . . . A little cinchona is also grown by planters. The value of their crops is out of all proportion to their acreage. In 1926-27 the value of the total exports, including spices, amounted to Rs.34.59 crores or about 18 per cent. of the value of all agricultural products exported. By far the greater part of this was accounted for by tea, the value of the exports of which amounted to Rs.29.06 crores.' (*Report*, p. 597.) A crore is 10,000,000 and a lakh is 100,000, of persons, things, or money : and the present value of the rupee is 1s. 6d. The Commission appends plantations to its chapter on horticulture as a special type of intensive agriculture, and it does not even raise the question whether the staples of agriculture such as cotton and wheat in the years to come may adopt the plantation system and thus cause Indian agriculture to exhibit a structure which would resemble outwardly the collective farms of Soviet Russia.

The Royal Commission on Labour in India of 1931 has four chapters on plantations, dealing respectively with general survey, recruitment of labour, wages, health and welfare. It studies them as a distinctive and important section of wage labour in a country where factory employment is relatively rare ; and it defines the system succinctly thus: 'The plantation system connotes the acquisition of a limited but fairly extensive area for the cultivation of a particular crop, the actual cultivation being done under the direct supervision of a manager, who in some cases may himself be the actual proprietor. A considerable number of persons (the number may run as high as 4,000) are employed under his control in the same way as the factory workers are under the control of the factory manager, but there is one important difference in that the work is

essentially agricultural and is not concentrated in a large building.' (*Report*, p. 349.)

The plantation has behind it a long history. It was the creation of the English overseas, beginning with the plantation of Ulster, extending to America and finding its modern home in the East. In old usage the word is synonymous with colony; and as Cunningham well says, 'English colonisation was, in its beginning and in its growth, the expansion of the landed interest.'<sup>1</sup> Now in early Canada and the early relations of England with India we are confronted not with plantations but with factories and forts, factories for trade and forts for the protection of trade. The plantation flourished in the West Indies and on the American sea-board, and was the economic instrument whereby colonies were established there. The *Commissioners of Trade and Plantations* embraced the two sides of imperial economy, trade by sea and plantation of the land.

On the mainland the first planted commodity was tobacco, which so monopolised the life of the southern colonies that they were called the tobacco colonies. Sugar held a similar pre-eminence in the West Indian islands. From the end of the seventeenth century the range of plantation produce was widened on the mainland. In 1694 rice was introduced into South Carolina from Madagascar; in 1745 indigo into South Carolina from Montserrat in the French West Indies; in 1794 sugar, the main produce of the West Indies, into Louisiana; in 1797, most crucial of all, sea-island cotton into Georgia from the West Indies *via* the Bahamas. But already before 1800 on the mainland, in contrast with the West Indies, the plantation had ceased to be the only form of agriculture exploited by settlers. The planter employing hired labour, at first white indentured labour and before long coloured slave labour, found a rival in the white settler employing only his family and himself. The free settler won in the end, and his triumph furnished the outstanding crisis of American social history. He was essentially a pioneer, and as the interior of the continent was settled, he and his type prevailed increasingly. The plantation, it was observed in early Virginia, hugged the tide water, whilst the free settlers pushed inland; this was typical of all plantation history. Apart from the short-lived reign of the great ranches, with their cattle kings, and of the bonanza wheat farms, the unit of enterprise in American agriculture has been small; and when the North by its victory in the Civil War ended slavery, it dissolved the plantation into similar small parts. The integrated enterprise of the slave owner gave place to a loose system under which tenants held on money or shares from indigent landlords and lived in a state of debt either to these landlords or to strong commercial middle-men. In the West Indies, as in Cuba, the sugar plantations survived, but the slaves freed in 1833 would not work properly on them, and their survival into modern times was only made possible by the introduction of coolie labour from the East. Our colonial empire is a great producer of sugar to-day, and the sugar plantation, though it exists in places, does not predominate on the whole. In all cases the organisation of production centres round the factory. But in the West Indies and Mauritius sugar factories buy both from

<sup>1</sup> W. Cunningham, *Growth of English Industry and Commerce*, vol. ii. pp. 119-120.



outside planters and peasant farmers, though sometimes they have plantations of their own ; and in Fiji, where the industry is under the control of the Colonial Sugar Refining Co. of Australia, almost all the cane used is bought from peasant farmers occupying their own lands or lands leased from the company. Only in British Guiana and East Africa is there in general that complete integration, to be met with in the tea industry, in which the cane is grown on estates connected with particular factories and under the same ownership and control. Nor is peasant cultivation falling away. The tendencies in recent years have been towards (i) increased size and centralisation of factories ; and (ii) greater development of peasant farming as the most economical method of producing cane.<sup>2</sup> Everywhere in North and South India one notices the small and isolated clumps of sugar-cane. Over broad, continuous sugar fields, one is told, the jackals would plunder without hindrance. There is thus a balance between large and small. Sir William Ashley taught us to recognise the complementary relation between first and final producers—the former large, the latter small, in the old-time textile and metal industries of England. In sugar we have a similar relationship, with the difference that the first producer is the small peasant and the final producer the large factory.

The course of land settlement in Australia was different from that in North America, being dominated by the large sheep run of the pastoralist, which has held its place in the Australian economy. The sheep property is, indeed, not a plantation, but structurally it is not far removed. It has a large area, it requires a manager and at certain seasons, though not throughout the year, it has an important labour force on it, the sheep-shearers. It may be owned by capitalists overseas, such as the Australian Estates and Mortgage Company, which administers sheep and cattle properties, operates stud farms and has an agency business as well. The desire for agricultural settlement makes these properties difficult to administer, especially at long range ; and while the large property may be a permanency in the dry interior, it is likely to disappear in time, at any rate as an investment for overseas capital, in other parts of Australia. Messrs. Drabble Brothers, the Buenos Ayres representatives of Geo. Fraser, Son and Co., of Manchester, a cotton business with which the writer's father was connected for over sixty years, formed with capital raised in Manchester the River Plate Estancia Company. After yielding 10 per cent. in dividends for many years it was wound up in 1910 as the result of the area coming into demand for building and other purposes, and over a million pounds was available for distribution among the shareholders of a company with a nominal capital of £80,000 only. Fruit-growing, however, has not been developed by the company fruit ranch. Alike in California and Australia, it is the stronghold of relatively small-scale and highly intensive agriculture. Perhaps if oriental labour had not been excluded from America and Australia, horticulture would have developed on the plantation pattern.

Outrivalled and dispossessed in North America, kept out in our own time by the policy of government from the tribal economy of West Africa,

<sup>2</sup> Cf. *Economic Survey of the Colonial Empire*, ed. 1935, p. 515.



the planters found a new home in the East : in particular in the British and Dutch East Indies. And to-day plantation denotes not only a system of agriculture but a system which chiefly grows plants from wood as opposed to plants from grass : tea, coffee, rubber, cocoa, coco-nut, cinchona. No doubt the capital investment required in raising wood plants has been instrumental in bringing these products under the plantation system, though it has not made it impossible for native growers, e.g. in rubber, to produce for themselves. There are no cotton or tobacco plantations in India and only a few sugar plantations ; and although indigo is a grass plant and provided the first form of plantation in India, it has all but disappeared through the supersession of indigo in commerce by aniline dyes. In method of exploitation, therefore, the plantation of to-day is closer to certain forms of forestry than it is to grain crops or roots. One may think of it with advantage as intensive forestry conducted in regions of hitherto sparse population.

## 2. THE HISTORY OF INDIGO.

Indigo and saltpetre are the two export specialties of Indian economic history : the former a crop yielding a textile dye, the latter a deposit, not a mineral but a human and animal deposit, used in the making of gunpowder. Neither is a foodstuff : and both have been superseded, the one by aniline dyes, the other by nitrate of soda (Chile saltpetre). Between Latin America and the Tropical East there has been a many-sided and age-long rivalry of supply. Cinchona and rubber were taken to the East from their habitat in South America, and the planted product of the East has ousted the wild product. Similarly, around 1830, in a battle of the insects, the lac of India, which yielded the scarlet red of soldiers' uniforms, displaced the cochineal of Central America. On the other hand, coffee, first supplied to the European market from Mocha in Arabia and later from South India, Ceylon and Java, to-day has its centre of production in Brazil, which provides 60 per cent. of the world's coffee and could easily provide the whole. Indigo has shared the same geographic pull. As the name signifies, its origin was in India, where the English and Dutch competed as merchants for the finished native product, but towards the close of the seventeenth century the trade was lost to Latin America, to reappear at the end of the eighteenth century, when there arose a new demand for 'navy blue' and when the West Indies were distracted by revolution, as in Haiti, or switching, as in the British West Indies, to more profitable crops such as cotton.

The revival of indigo production towards 1800 was the work of European planters in Bengal ; and they were assisted by the East India Company, which advanced large sums of money to the industry, encouraged its servants to take up planting, and relaxed, in favour of the planters, its monopoly of trade. Hitherto the Europeans had been merchants, buying in certain markets of West, North and East India the village-made product. The planters of the seventeenth century were the peasants themselves, but they were not independent producers. For the Dutch trader, Pelsaert, writing in 1626, states that when supply is

short, it is prudent to avoid running around the villages, as the hungry Armenians do, and better to buy in the town 'from the substantial Hindu or Moslem merchants who live there and have been many years in the trade, and who have made advances against indigo some months beforehand, binding the debtors to sell to no one else.'<sup>3</sup> The European planters took the place of the Indian merchants and something more: for they set up factories in the areas of supply and manufactured the raw produce by improved machinery, drawing on the personnel and practice of the West Indies. Like Samuel Oldknow in eighteenth-century Lancashire, they advanced from merchant capitalism to factory ownership. As the land was already in the hands of the ryot, they were not able to set up the slave plantation system, in which the planter owns and operates both factory and land; and they endeavoured to ensure supplies by intensifying the debtor relationship which existed already between native merchants and native cultivators. They made advances of money which gave them a lien on the ryots' crop at a fixed price and reinforced their position as creditor by acquiring zemindar (landlord) rights over the cultivator. Sons succeeding to their fathers' property and debts inherited, so they believed, the compulsion to grow indigo. This was what the ryots detested and the planters desired; for, as one of the latter observed in 1860, 'to encourage any ryot to pay off his balance would be virtually to close the factory.'<sup>4</sup> The situation became intolerable when the planters, having formed a Planters' Association, divided up the territory and maintained a fixed price which was much below the cost of production at a time when other crops and the expenses of cultivation in labour and draught animals were rising rapidly. The result was a growers' strike, accompanied by disorders, which led to the appointment of a Royal Commission, and its Report of 1860 is a document of the first importance. It shows that the planters had been guilty of illegal seizures and detentions of ryots, and that the contract to grow, though believed to be hereditary, was not really so. It evinced a determination to protect the peasant, but was so dominated by current doctrines of non-interference that it was opposed both to penal legislation against the cultivator and to any protective legislation in his favour that 'fetters the free agency of the contracting parties.'<sup>5</sup>

But throughout the nineteenth century the indigo planters owned some land and to that extent were true planters. This was called *Nij-joti* ('it may be likened in some respects to a home farm managed by the proprietor of an estate in England'),<sup>6</sup> and the majority of it was on land of new alluvial formation annually inundated and occurring mainly in Eastern Bengal. On this class of land indigo was the crop most suited to the soil, and there were few disorders here in 1860. But so long as the ryot was compelled to deliver indigo at much less than the cost of production, the major part of the supply was virtually subsidised, and the Lieutenant-Governor of Bengal, in commenting on the findings of the

<sup>3</sup> F. Pelsaert, *Jahangir's India*, ed. Moreland, p. 16.

<sup>4</sup> *Report of Indigo Commission, Parliamentary Papers*, 1861, XLIV. s. 109.

<sup>5</sup> *Ibid.*, s. 188.

<sup>6</sup> *Ibid.*, s. 20.



Commission, pointed out that 'the real planter who grows and manufactures his own plant is, in fact, injured by the manufacturer who under-sells him, because he gets his plant at a less price than any free system cultivator in his senses would grow it for.'<sup>7</sup> However, both he and the Commission believed that it would be impossible for *nij* cultivation to replace ryot cultivation, even if the contract system was abolished, inasmuch as the ryots were already in possession of the good lands and planters could not here obtain compact estates. It would be a slow business for the planter to move his servants and ploughs from place to place, whereas the ryot on the spot could turn out with his own plough and sow the moment the weather was favourable. Therefore, after 1860, the planters were still dependent on the ryots and now assured themselves of supplies by procuring leases or other forms of control over ryot land. A planter would make loans and receive as compensation a sub-lease of the ryot's holding, thus becoming often a sub-tenant of his own tenant, over whom he already had general zemindar rights. It was only towards the end of the indigo period that the full plantation system was adopted, immigrant hillmen working in the factories and their women and children in the planters' fields. In 1890 about half of the 240,000 acres under indigo in Bihar was thus cultivated.

Inasmuch as indigo was superseded by synthetic dyes, we must turn to a commodity in new demand on already occupied land, to find out how a prosperous indigo industry might have evolved under twentieth-century conditions. Tobacco furnishes a good example. The British-American Tobacco Company, through its associated companies, is something more than a merchant and manufacturer in India, yet it is not a planter. The centre of its operations is Gunthur in Madras Province. India is, after the United States, the greatest producer of tobacco in the world, and the great majority of it is consumed locally. Of some 900-1,000 million lb. of Indian tobacco, the British-American Tobacco Company handles about 40 million. Its task has been to introduce tobacco of the Virginian type to Indian consumers on the lines of its earlier work in China, and then, under the stimulus of a protective tariff, to manufacture this kind of leaf in India itself. Its problem was to secure adequate supplies of the right type. Therefore, in addition to its factories, it has a Leaf Development Company, which teaches the ryot how to grow improved varieties and supervises the growing. The seed is issued by the company's staff of expert botanists, and the company contracts to purchase crops of selected ryots whose output can be expected in a normal year to reach a certain figure. It thus exerts in a paternal way the influence which Messrs. Chivers, fruit and jam manufacturers at Histon, Cambridge-shire, exert on the surrounding fruit growers. When the indigo planters tried to improve their product by the issue of selected seed, the ryots refused to take it, lest this should count as a money advance of the old type, which would put them in permanent bondage. But the British-American Tobacco Company has no such designs on the peasant and his land. The ryots grow the new varieties eagerly and well; and I saw the rich green of the highly cultivated tobacco land around Gunthur.

<sup>7</sup> *P.P.*, 1861, XLV. s. 25, p. 76.



A second example is supplied by sugar. For in India since the war sugar-cane production has been increased by the aid of tariffs and subsidised sugar factories. The research stations of the Government, e.g. that of Heppal outside Bangalore in Mysore State, play the part of leaf development companies to the suppliers of sugar. What rôle co-operation among growers may one day play in tobacco and sugar is hard to forecast. I suggest that, co-operation for credit apart, it will take the form of a collective bargaining association, as among the milk producers of America, rather than of a processing organisation like that of the fruit growers of California or the dairy farmers of Denmark and New Zealand. The capitalisation and technique are too advanced to allow of the peasant undertaking the co-operative management of sugar factories. In tobacco, as contrasted with butter or sugar, a further difficulty is present. It is exceptional for any tobacco product to be manufactured exclusively from a single grade of leaf. Nearly all are blended from a variety of leaves possessing different qualities, and the expert blender, who makes these mixtures, must be satisfied that the leaf offered to him possesses the qualities which he requires.

### 3. TEA AS A COMMODITY.

The bulk of the tea consumed by Great Britain is grown in one of three districts, Assam (with adjoining territory), South India and Ceylon. Java is a competitor in lower-priced teas, and China grows its special China tea. The production is highly localised, and tea tends to drive out any rival. Climate and altitude are important, and Ceylon is favoured in both respects. First of all it has two monsoons: the south-west, June, July, August, September; and the north-east, November, December, with the tail end in January; and the rainfall is sufficient to promote growth virtually the whole year round. In Assam, which is outside the Tropics, there is only the one monsoon, the south-west; and for a part of the year there is no growth owing to the winter cold, and the plantations are closed down. South India has a shorter off-season, though in parts there may be a five-month drought, when growth is slow. Of Ceylon, though not of India, it may be said that the higher the land the better is the quality of the tea.<sup>8</sup> Just as in Canada the best apples are grown near the frost line, so in Ceylon the best tea comes from the high land. Ceylon distinguishes between three classes of plantation land, the low coastal land which is devoted to coco-nut plantations, the middle land which has rubber, cocoa and tea, and the high land which has been all but monopolised by tea since tea, fifty years ago, took the place of coffee. But even in Ceylon the range of tea is wide; and the Colombo market reports distinguish between high, medium and low elevation teas. The handicap of Ceylon is its relatively small area and the consequent high price of land. In South India along the Western Ghats plantations are of more recent growth and there is

<sup>8</sup> The tea plant grows wild in the lowland jungle of Assam, and perhaps the finest tea in the world is grown in the Brahmaputra Valley at only a little above sea-level.

more room for expansion. On the middle land in Ceylon tea and rubber are seen side by side, but the interplanting of tea with rubber is rare. After the rubber slump of a few years ago a certain amount of interplanted rubber was removed and the whole left to tea. Strong regionalisation, conforming to natural requirements, has been reached as the outcome of experience.

The Royal Commission on Labour in India continues: 'Factories are to be found on certain plantations. Most tea gardens have their own factories for dealing with the harvested crop. A number of the coffee plantations in South India also have their own factories, but in them the process of manufacture is only a preliminary stage, the coffee being cured and finally prepared for export in factories outside the plantations' (p. 349).<sup>9</sup> This quotation calls attention to an important feature in tea. Every tea estate has on it, or adjoining it, a tea factory; and in this factory tea leaf is carried to its final processed form. When it arrives overseas, it only has to be blended to be ready for consumption. Moreover, when blended it is ready for final consumption. It is not, like cocoa, the raw material of a further industry such as chocolate. Coffee again is different; for on the coffee estate processing is confined to the removal of the two coffee berries from the containing skin or cherry. When the cherry has been removed, the berry is sent in parchment form to curers on the coast, and finally is roasted and ground overseas. The coffee estate is very far from turning out the finished article. Similarly with rubber the latex comes in liquid form from the trees and, after the impurities have been strained off, it is coagulated into sheet or crêpe rubber, baled and exported. These processes require a very elementary factory in comparison with the sequence in a tea factory or rubber and tyre factory.

As a plant, tea is distinguished by a further feature. It is a leaf and not a fruit, and its yield is both continuous and reliable. It is like having one's hair cut every week or fortnight. But a fruit such as the orange or the coffee berry has a flowering season, and damage to flowering may hurt the crop beyond remedy, whereas in a foliage crop, although certain conditions may arrest growth and hurt the quality, yet these adverse conditions may be followed by good conditions favourable to further growth and a restoration of quality. Finally, because it is a leaf no spraying is possible. To spray a whole tree would be too large a task and might leave deleterious matter on the leaf. Of course, when the tree is being pruned and out of use, this objection does not hold.

#### 4. THE TEA FACTORY.

Let us enter a South Indian or Ceylon tea factory and watch the sequence of operations.

1. *Withering*.—The leaf on entering the factory is taken to lofts where it is spread on tats, strips of hessian cloth on which the leaf is thinly spread. It remains here for a minimum period of eighteen hours, after which it is in a withered state. The required degree of wither is checked by

<sup>9</sup> Tea 'gardens' I take to be the language of China and Assam. Does it derive from the time when tea was grown by the villagers of China in little gardens?



one of the factory staff, and should be taken to a stage of approximately 58 per cent., 42 per cent. of moisture being removed. In certain conditions of weather it is necessary to wither the leaf artificially by hot air. Modern atmospheric conditioning plant working automatically opens up great possibilities for the future. One thinks of the perfect control given by the 'humidifier' in the modern cotton mill.

2. *Rolling and Breaking*.—The leaf is collected and fed to a roller consisting of a large box-like arrangement with a brass table. About 350 lb. are taken on to a roller and rolled for three to five periods of about half an hour each. The object is to put a twist on the withered leaf and to break it up gently. The small leaf passing through the mesh is collected and taken away to a cool room to ferment. This is called 'fine bulk.' The bigger bulk, which is carried off the end of the roll breaker, returns to the roller, where the process is repeated. This is called 'coarse bulk' and goes also to the fermenting room. Over-rolling would reduce the leaf to a mush and break the fine tips.

3. *Fermenting*.—In the fermenting room the leaf is evenly spread on a tray and exposed to air. The object is to improve the liquor and flavour of the tea under chemical action. It takes about three hours, and at a certain stage the leaf gives out a smell which informs the tea-maker that it is ready to be fired. If it were left for twenty-four hours, it would be ruined and the smell would be offensive.

4. *Firing*.—The tea is now passed over revolving trays, dropping from one to the other. As it goes over the trays, hot air is passed continually through it. The object of firing is to make the tea black and crisp, and the process corresponds to the roasting of coffee. It is now quite black. Green tea comes from the same plant; but if green tea is required, the leaf is heated by steam to a degree at which fermentation cannot occur and stays green in colour.

5. *Sifting and Packing*.—On the next day the teas thus made are taken to another room on the ground floor, where they are sifted and cut and sorted into a series of evenly graded clean teas, the final products being classified thus: broken orange pekoe (B.O.P.), broken pekoe, pekoe, pekoe su, B.O.P. fannings, B.P. fannings, dust, fluff (this comes from the hairs on the tip of the leaf and, though formerly used as a dye, is now used only as manure). 'Orange' pekoe is so named because of the bright golden pieces of tea, which are the buds of the bush. The *Oxford English Dictionary* says, under 'pekoe': 'Chinese, from *pek* white + *ho* down. A superior kind of black tea, so called from the leaves being picked young with the down still on them.'

## 5. THE TEA PLANTATION.

We step now outside the factory to inspect the factory from without and the estate itself.

The factory, with its roof and walls of corrugated iron, painted brick-red or left plain, has a basement of brick and mud and cement floors, and it is built on steel framework panelled with wood. It is not so gaunt as a grain elevator in Canada, and its background is always pleasing. It



will be a little way inside the limits of the estate, and usually near the bottom of it, and it is reached by a winding road. Near-by are the superintendent's bungalow, the coolie lines and a store. The chug of the engine is audible some distance away.

Where, as in tea- or butter-making, the raw material is processed close to its place of growth, the conveyance of the raw material to the factory is economically important. There are five different ways in which the tea leaf may come to the factory : (1) the whole way in baskets on the heads of the girls, to be weighed at the factory door ; (2) on the bullock with side bags, which is now out of date ; (3) in the bullock cart ; (4) on the wire shoot, using gravity, with overhead carriages, resembling the apparatus on which cheese is slung in the Alps ; (5) in the motor truck. The truck is now ousting the bullock cart and represents the best modern practice. The tea is weighed from the basket into the truck at the roadside, and the babies are fed at the same time ! Lorry leaf, because it comes so expeditiously, arrives in better condition. Similarly, the source of power for the operation of the factory is closely bound up with its neighbourhood. The usual fuel is wood taken from the jungle, or stump wood from the estate itself, when it is being cleared. Wood fuel favours the dispersion of factories in such a way that each will have around it an adequate fuel supply. The wood is used in two forms : (1) as heated charcoal, made by estate labour, which gives off gas for the generation of power in an internal combustion engine ; (2) as logs for firing the furnaces which heat the pipes through which air is taken into the drying machines. But in the Anamalais (South India) group of the English and Scottish Joint Co-operative Wholesale Society, Ltd., three factories have been recently electrified to take power from the Pykara Dam, and in its Manantoddy group the possibilities of Cauvery water have been considered. Ceylon is rich in hydro-electric power, but very little has been developed. Any general adoption of hydro-electric power would be a force favouring the concentration of production at one or more central points in a group of estates.

The work on the estate embraces three distinct tasks : (1) clearance and planting ; (2) cultivation and soil conservation ; (3) the plucking of the leaf.

(1) A planter must be an engineer, road-builder, technical agriculturist and labour manager all in one ; and at the outset a labour force must be assembled which is ready to turn its hand to every task that is required. The area to be cleared is first of all surveyed for roads and levelled. The jungle wood is felled, dried and burnt ; unburnt residue being cut up and reburnt. Large roots are taken out. Lines are then laid, normally north-south, and pitted for tea bushes. The estate is roaded, drained and planted. All this requires a period of about six months, from felling in October to planting in May, in readiness for the south-west monsoon. In the same interval protective trees are planted.

The tea seed either is raised in a nursery and the plant lifted after eighteen months or more, or else after germination it is put in a basket in which it is shortly taken to its position in the field. It is then left to grow for a period (during which the planted area is weeded, dug and cleaned),

and after a light pruning yields tea. Whether it is nursery or basket plant, the interval between planting in the field and coming into bearing may be reckoned at  $2\frac{1}{2}$  to  $4\frac{1}{2}$  years, according to climate and elevation. Thenceforward the trees are pruned on a two- to three-year cycle: the object of pruning being to control the tree and get an even spread of leaves. It is a serious operation, to which only healthy trees respond properly. Bushes in use are 3 to 4 ft. high, but left wild they would grow to a height of 20 to 30 ft. or more, and would have small white flowers all over them at blossom time. It is interesting to remember that in New Zealand in spring the white flower of the manuka shows up prominently. It is called the tea tree because the earlier settlers made a drink resembling tea from it, and it is sometimes spelt incorrectly 'ti' tree, as though it were a Maori word.

(2) An estate in bearing is cultivated each year as well as pruned periodically. Growth is permitted during the wet season to resist erosion, but after the rains must be cleared. The digging is done with a four-pronged fork, and its purpose is to turn and aerate the soil, bury weeds and absorb water. (In parts of South India the division of labour is carried to the point at which two men work one spade, one man inserting and raising the spade, and another jerking the contents to one side by means of a small cord attached to the neck of the spade.) In pruning the branches are cut away and stacked in rows, and, when the foliage has dropped, they are removed for firewood or manure. The leaves themselves are scraped into heaps and forked in with the help of the worker's feet above the bushes. Compost manure is humus made from the waste products of agriculture such as leaves, sweepings and cattle dung. Heaped rubbish engenders great heat, takes up nitrogen and kills lice. It is finally dug into the soil between the bushes, say five tons to the acre. The value of this organic manure is now generally recognised, and it is customary to apply it with a chemical concentrate such as bone meal and potash.

Though tea is the only plant on the estate grown to yield a cash return, yet there are other trees planted on it to help the tea tree by way of protection and nourishment. The most common shade tree is the tall grey *Grevillea robusta*, commonly called the silver oak. The stouter *Albizia* yields good wood as well as shade. The *Dadap* is a quick-growing nitrogenous shrub, which is lopped for its leafage. In Ceylon a common catch crop is the yellow-flowered *Crotolaria*, which is cut down and forked in. The deciduous leaves of the *Grevillea*, when they lie on the ground, protect the soil from the baking effects of the sun and act as a mulch, preventing soil washing.

There is thus on the estate, even when cleared, a continuous programme of cultivation, which is done by male labour. Any slackening of cultivation is punished by attacks from couch grass, allock, lantana and other noxious weeds. These have to be eradicated by continuous forking and burning, after which it is possible to re-establish high-shade, medium-shade and green nitrogenous plants.

(3) Tea-plucking falls into two parts. The first plucking is on the young trees to bring them to a level, and it is done three times over. Then comes



the regular plucking once every week or ten days or more until the tree is rested for pruning—provided of course that, as in Ceylon, all-year picking is possible. Only the tips of the bush ('two leaves and the bud') are picked. The small tap leaf (which is about the size of one's little finger), together with one leaf above that, is left on the bush, and only the tender leaves at the top are taken for manufacture. Inside these leaves rests the orange-coloured bud. The lower leaves would be too coarse and bitter; they are not left because of any scheme of restriction.

Plucking is done by women under the supervision of a *maistry* or foreman, and is the crucial operation on which the wage economy of the plantation rests. It corresponds to the shearing of sheep, the harvesting of wheat, and the stripping of cotton. Shearing is done once a year by itinerant shearers using machine clippers, harvesting by the aid of the harvester which both strips (or cuts) and thrashes, cotton-picking either by hand or by the mechanical stripper. But there is no machine for tea-picking, and for technical reasons there is never likely to be one. If there were, it would upset the balance of the labour force. For the men workers and women workers with their families live and work on the estate.

#### 6. OPTIMUM SIZE AND THE AGENCY SYSTEM.

What is the optimum size of the tea plantation? The figure generally given for a mature estate is 500 acres. In East Africa, where tea-planting is new, there is no restriction of export as such, but a recent arrangement<sup>10</sup> provides that planters with 100 acres and upwards shall be allowed to expand to 500 acres, which is conceived of as the working optimum. In India and Ceylon it was determined historically by the capacity of the individual planter in pre-motor days to finance and supervise the development of the estate, its cultivation and working and the treatment of its product in the factory on the estate. With primitive roads and bullock carts the daily delivery of the leaf made an estate of much over 500 acres impracticable; and many private estates lacking finance would remain smaller than this. But the days of the proprietary planter are over, and now one meets not with planter owners but salaried superintendents—one superintendent to each estate. Moreover, several estates, say two, three or four, are grouped together to form a 'group' with a group manager. The latter superintends the other estates on his group and in addition manages one estate directly. A large company will have a number of groups in different districts.

Normally the position still is one estate, one tea factory, but not always. There is a growing tendency for the factory to be enlarged, so that it can take the produce of several estates. For example, recently in the Sheikal-mudi (Anamalais) group of the English and Scottish Joint Co-operative Wholesale Society in South India, four estates have been feeding one factory, and the two factories thereby put out of action are kept as stand-bys for use in the rush season. From the estate superintendent's point of view this development may be unwelcome. As one of them (not in this group) said to me, 'You will have no end of complaints about

<sup>10</sup> *Report of the International Tea Committee, 1934-35, p. 7.*



the quality of your tea if you do not make your own leaf.' Mechanical transport and electrical operation indicate a figure closer to 800 than to 500 acres as the optimum size of a single estate in the future.

As the result of evolution there are four different types of plantation to-day.

1. *The Proprietary Planter*.—He is almost extinct. The man who is called a planter is in fact a salaried superintendent. In 1909-10 perhaps 30 per cent. of the planters were proprietary planters (except in the coco-nut plantations, which have always been either a village or a company enterprise). But to-day it is rare to meet one.

2. *The Small Companies*.—These, with their agents at the coast, are the most representative type of plantation in Ceylon to-day. They have their London shareholders and directors and their agents in Ceylon, and they may employ the services of visiting agents to report on the condition of the estate from time to time. I visited the estates of two such companies: the Nayabedde Estate Company Ltd. at Passara, Ceylon, and the Dimbula Valley Tea Company Ltd. at Bearwell, Ceylon.

3. *The Large Companies*.—Examples are the Ceylon Tea Plantations Ltd., which acts as its own agent, and the Anglo-Ceylon and General Estates Ltd. These large companies produce rubber and coco-nut as well as tea, thus diversifying their interests. The Ceylon Tea Plantations Company has the following acreage in bearing: tea, 9,456; rubber, 5,193; coco-nut, 2,414 acres. Its profits for 1935 were £54,000, dividend 10 per cent., by comparison with the prosperous days of the 1920's, when—e.g. 1925—profits were £332,000 and dividend 60 per cent.

4. *The Consumer Companies*.—These companies have in Great Britain their own wholesale and retail organisations for the disposal of tea, and they operate estates from which they derive a portion of their supplies. Such are Lipton, Brooke Bond, and the English and Scottish Joint Co-operative Wholesale Society.

The small companies above mentioned could hardly exist in their present small form if they were not commercially integrated by the great coastal agencies. These agents play a dominant part in the commercial and industrial life of the East. The evolution of their contact with plantation agriculture may be studied in the indigo industry. 'They [the Calcutta agency houses of the 1830's] also became Calcutta agents for the plantations and received commissions on purchases and various other transactions, including 2 per cent. on all sales. Mortgages were taken on the property, but the risks were great. The investments in buildings and land were not nearly so substantial as the outlays for advances to cultivators.'<sup>11</sup> And there is a strong analogy in the stock and station agents of Australia and New Zealand, like Dalgety, Goldsbrough Mort and the New Zealand Loan and Mercantile Agency, which have served as the financial spine of the pastoral industry in those parts. The agents' functions are very miscellaneous. They act as shipping agents, as import agents and as export agents. Some of them are almost exclusively connected with plantation produce, and in particular with tea. A large agency

<sup>11</sup> D. H. Buchanan, *Development of Capitalistic Enterprise in India* (1934), p. 37.

firm will be agent for perhaps forty or fifty plantations, they may have a financial interest in them, and though not technically the managers of the estate they may be virtually so. They supply their estates with planters' requirements and they handle the produce of the estates, selling it at the auctions in Colombo or sending it to London for auction there. At the auction they are present both as buyers and sellers, and if the lot of tea on offer comes from one of their own estates and they want it for a customer, other buyers (I was told) do not bid against them. Leading agencies are: Harrison and Crossfield, James Finlay & Co. of Calcutta, Carson's of Colombo, George Steuart & Co. of Colombo. The managing agency is applied in India to factory industry also. But whereas in factory industry the commission is usually paid on a profits basis, in plantation industry it is paid on a quantity basis, calculated on purchases, shipments or sales. Its penetration is, therefore, less complete here: the agents manage the plantation in an indirect fashion only.

The English and Scottish Co-operative does not employ agents. It started on the coast as a merchant and then pushed inland to own and manage tea estates, the produce of which it despatches to the English and Scottish Wholesale Societies, who jointly own it, in Great Britain. It procured its estates by the purchase both of planted and unplanted land. The nucleus of its South Indian properties was bought by Sir Fairless Barber, who later became the general manager. In Ceylon it sent its commercial manager from the Colombo depot to take charge of its estates when it acquired them there. Being structurally a buying agency which has pushed inland, the English and Scottish Co-operative has naturally followed other agents in developing an inward as well as an outward business. Not only does it supply its estates with requirements, but it also in Calicut does a general business of import, selling to wholesalers in the district. It sells where it can the products of the factories of the Co-operative Wholesale Society itself, but except in proprietary lines this has not been easy to develop owing to Japanese competition. A similar attempt with somewhat similar results has attended the efforts of the Co-operative Wholesale Society to develop a reciprocal trade between itself and the dairy farmers of New Zealand.

## 7. LABOUR CONDITIONS.

Where tea is grown in hilly regions or in an area that has hitherto been jungle, the problem of labour is in the first instance one of recruitment from a distance. It is a special case of that larger problem which we call migration. Migration is of two kinds: from village life in one country to village life in another, and from village life to town life inside the same country. Estate labour migration comes midway between the two. It is migration from one rural existence to another, but the discipline of the estate is not far removed from that of the urban factory. However, unlike many factories, the plantation requires the whole labour force of the family, the terrain is rural and the environment is pleasant. There is thus in plantation labour no marked hostility to the employment as such. The workers are not thinking the whole time of the village at



home to which they will return when they have made enough money. In time the plantation becomes their home, and the return to their own country is a holiday away from home rather than an escape to it.

The problem of recruitment differs according to the area. First, North India. In the Darjeeling area much of the land is too high for the plains people, and the labour is derived from the voluntary migration of near-by hill peoples from Nepal and Sikkim. Many of these workers have lived on the estate since birth.<sup>12</sup> Assam was the difficult district to settle. Seventy years ago it was uncultivated, and nearly uninhabited, jungle. It was a rude and insecure region close to the frontier of India. In the nineteenth century planters had to obtain and hold their labour by a system which had many harsh features in it. It was virtually a system of indentured labour with severe penal contracts attached. Recruitment was prohibited in certain districts outside Assam—for example, in parts of the United Provinces—and the planters obtained their main labour from primitive tribes people of the Santal Parganas and Chota Nagpur by methods which degenerated at times into a system approaching to slavery. Even before the war this was greatly changed. The penal contract had been modified, and propaganda and advertisement by recruiting agencies forbidden. There has, however, to be some method of recruitment, and, in the absence of organised agents on the one hand or a Government system of labour exchanges on the other, there grew up a highly expensive system of informal recruiting by the foremen of the estate, themselves ex-workers. Under this system it cost before the war Rs.200 to Rs.500 to recruit one labourer, and in 1930 Rs.150. The foreman (*sardar*) abused his position. About one-half of them did not recruit a soul, and about one-third did not even return themselves, according to the Royal Commission in 1931. Moreover, it became customary to make everyone who was returning home a *sardar*, because that was the simplest means of assisting his return. 'It is only in the case of Assam that neither the employer nor anyone else can assist the labourer who is willing to migrate except by the expensive and cumbersome expedient of sending down a garden *sardar* to sponsor the recruit.'<sup>13</sup> The Commission therefore recommended that a recruiting body representing Indian as well as European planters should be allowed to open recruiting depots, and that assisted recruits should not be forwarded except through these depots; while, to protect the workers on arrival, a Protector of Immigrants with powers to work inside Assam should be appointed. The problem is likely to diminish; for it is computed that over 600,000 ex-garden labourers were settled on Government land in Assam in 1921, the total number of foreigners in the province attributable to the tea industry being one and one-third million, i.e. one-sixth of all Assam. With tea restriction and the acclimatisation of foreign-born workers to Assam they will to an increasing degree find a place of retirement within Assam itself.

The position in South India is rather different. The country is newer,

<sup>12</sup> The Dooars, a submontane tract to the south of Darjeeling, derive their labour from the same sources as Assam, but there has been no penal contract.

<sup>13</sup> *Report of Royal Commission on Labour in India*, p. 70.



and the problem of recruitment is easier because in Madras Province, and especially in Malabar, there is a great mass of labour seeking work. The existence of 'distressed' areas, where poverty was extreme and perennial, facilitated recruitment at the outset. The labour comes to the estates and returns to a near-by home once a year, for the tea year is a ten-month year, and in the two idle months the workers go home. This is the inland side of that great overseas movement which until recently took place year by year from the west coast of Madras to the rice fields of the Irrawaddy Delta in Burma.

In Ceylon there are, from an agricultural standpoint, four distinct divisions of population: (1) the European commercial and planting community; (2) the native Sinhalese, who are the officials, the lawyers, and the ordinary agriculturists of the island, but though some Sinhalese are employed incidentally on the estates, they are rarely part of its labour force; (3) the old immigrants from South India, the Jaffna Tamils, who are also agriculturists—Jaffna being a rich agricultural district which, *inter alia*, grows tobacco for the South Indian market; (4) the estate labourers, also Tamils from India, who supply the labour force of the estates. It is estimated that in 1935 the estate population of men, women and children numbered 688,000, or one-ninth of the island population. The movement of labour is strictly controlled, and there are no abuses. They have paid in the past periodic visits to their old homes, but more and more the younger workers are coming to regard the estate where they work and perhaps were born as their home.

I did not visit Assam, therefore I will draw my examples of wages and living conditions from South India and Ceylon. In South India the methods of wage payment (16 annas = R.1, 1 anna = a penny) are as follows:

A male worker earns 6 to 7 annas a day and is given a definite task of digging, etc., to perform in the working day. The women work by piece-rate, so much per pound of green leaf plucked. In the hot weather, when the crop is short, they may earn only 2 to 3 annas a day, but in the flush season perhaps a rupee. Under restriction the working week is a five-day one, with no plucking on Saturday or Sunday. The earnings of the worker are not, however, paid out each day or week, or even each month. They are credited to him or her on the worker's check roll account and paid out as follows: each week to each man and woman 4 annas for the whole week (also 2 to each working child), this payment being called *selvado*, together with a ration of rice, say 11 annas' worth per adult worker. During the season one or more advances will be made to enable the worker to pay off village debts or to incur some outlay, such as purchasing a marriage *sari* (dress). Finally, at the end of the season, the worker draws a lump sum in cash, being the balance of what is due to him after all deductions. This sum the workers take home with them, but it is said that many are already so greatly in debt to a near-by money-lender or trader that the lump sum earned is in their possession only for a moment.

In Ceylon (100 cents = R.1, 6 cents = a penny) the system is different. First of all there is a legal basic rate, which is fully enforced.

Secondly, payment of the whole wage due is made once a month, the standard rates being as follows :

|                        | Cents a day. | Rs. a month. |
|------------------------|--------------|--------------|
| Man . . . . .          | 50           | 11           |
| Wife . . . . .         | 40           | 9            |
| Two children . . . . . | 30           | 14           |
|                        |              | —            |
|                        |              | 34           |

Careful estimates of budgets have been compiled, to ensure that the wage rate is sufficient for reasonable subsistence. The monthly expenditure is calculated as follows :

|  | Rs. | Cents. |
|--|-----|--------|
| Rice 1 bushel at current rates for the man . . . . . | 4   | 40     |
| „ $\frac{3}{4}$ „ „ „ „ „ wife . . . . .             | 3   | 30     |
| „ 1 „ „ „ „ „ 2 working children . . . . .           | 4   | 40     |
|  | 12  | 10     |

A further Rs.7 and 50 cents is allowed for other grains, such as gram, dhal (a pea), and soya beans. Thus the family bill for the main food-stuffs is about Rs.20 a month against a family income of Rs.34. To this must be added expenditure on oddments such as chillies, spices, sugar. I inspected the edibles in several of the co-operative stores run by the planters on their estates, and they represented over half the total trade of the store.

The remaining trade was in cooking vessels made of clay, and clothing, of which the chief items were *saris* (women's dresses), *vertis* (men's skirts), shirts, loin cloths, head cloths, and rain shawls with hood attached. The *vertis* and head clothing were the only products coming from Lancashire. The shirt is frequently native- or Indian-made, from homespun *khaddar*. But the bulk of the clothing is Japanese. When, in pursuance of the Ottawa agreement, textile quotas were imposed by proclamation on Japanese textile imports, as from July 31, 1934, the Japanese in part got round the quotas by sending in the finished article, which was not quota'ed, instead of piece goods. 'The imports of Japanese made-up apparel have intensified during the past three years. This development not only represents an increase of possibly 50 per cent. of the Japanese quota, but has also caused considerable hardship to the local tailoring community.' <sup>14</sup> I found a widespread condemnation of the textile quota. It came at a time when the earning power of the population had been heavily reduced by distress and disease, and it was forced by London on Colombo. But for the reduced cost of clothing due to the Japanese imports the real earnings of the working population of Ceylon, and in particular those of the general agricultural population, whose returns vary with the price of their produce, would have fallen below subsistence level after 1929.

It is noteworthy how frequently the Royal Commission on Labour in India quotes with admiration the methods of Ceylon. The tea company itself, the Ceylon Government and the Government of India's agent from Madras (who resides in Kandy and is entitled to visit the estate and

<sup>14</sup> Extract from the *Ceylon Customs Administration Report of 1935*.



inspect pay-sheets) all look after the coolies' welfare. And when Indian planters objected to this or that proposal, the Royal Commission was able to argue with effect that this very proposal had been introduced in Ceylon at the demand of India's representative in Ceylon, so that India was only being asked to follow the practice which she had helped to impose on Ceylon.

I was in Ceylon at the tail end of the great malaria epidemic, which, in conjunction with famine, in the space of a year and a quarter destroyed around 100,000 lives. A full account of its cause, course and consequences is given in the Reports of Colonel Gill of the Indian Medical Service (September 1935), of Dr. Briercliffe, head of the Medical Department of Ceylon (September 1935), and of the special relief Commissioner, Mr. H. E. Newnham, Ceylon Civil Service (March 1936). Dr. Gill emphasises the cumulative damage wrought by the epidemic. First, the actual sickness and mortality which attended it. Secondly, the accompanying privation and starvation. Thirdly, the paralysis of village life. Fourthly, the debility and sickness consequent upon it. The cause of the malaria epidemic, as well as of the famine, was the abnormal drought of 1934 and 1935, so that rivers which normally flowed strongly were reduced to stagnant pools in the sand and rock of the river-bed. In these the mosquito (*Anopheles culifacies*) found an ideal breeding ground. Malaria is endemic in parts of Ceylon and in the East generally, but there was no epidemic in those parts of the country which normally suffer the most. The epidemic was confined to certain river systems, flowing in the main to the west coast. The area included all but the higher situated tea plantations. At the height of the epidemic in certain regions every other person was stricken. It was the duty of Mr. Newnham to organise the programme of relief. He testifies in his Report to the excellent response of the native self-governing legislature in the crisis and to the honourable conduct of the large majority of those who were relieved. He quotes cases of abuse, but they were in the minority, and he is able also to quote cases of villagers refusing supplies, on the ground that the needs of their neighbours were greater than their own. The blow to the economic life of the country was so complete that it was necessary to organise relief works. The lack of technical experts in sufficient numbers was found a major obstacle in instituting suddenly a largely increased programme of road building. Moreover, the workers were themselves in poor condition. Therefore at first anti-mosquito measures, such as clearing stagnant water and spraying river streams, proved the most suitable light work to those recovering from malaria. In addition to clearing streams they removed undergrowth, filled hollows and burnt rubbish. Thereafter they were employed on road-making and irrigation works. But the financial drain on the State was heavy and, though aid was given freely while the crisis lasted, the State Council felt compelled to curtail its works programme as soon as these were unnecessary for relief; and Mr. Newnham laments the resulting loss, for 'meanwhile the rain descended and the floods came and beat upon the earthwork, and for want of culverts, etc., some hundreds of miles of roads were becoming derelict.'<sup>15</sup>

<sup>15</sup> *Report*, p. 37.



Colonel Gill's Report emphasises the fine work done by the planters. Both in South India and Ceylon the hospital facilities on the estates are of a high order; for the planters have to maintain a continual fight not only against malaria but also against the hook-worm, which enters through the bare feet of the workers when they tread on infected matter. During the epidemic the planters took charge of their own people and also of adjacent villages. Dr. Gill concludes that in certain rural areas, and more especially on estates, the prevention of malaria epidemics is a practicable proposition. He ventures the opinion that another major epidemic is unlikely within the next five years, and meanwhile he submits a programme of preparation and co-ordination of effort. It is useless, for example, for the planters to clear their estates if the neighbouring village land continues to breed the mosquito.

A final thought emerging from this crisis concerns the relation between plantation agriculture and village agriculture. Too often the hope of village agriculture is thought to lie in the export market when there is a better one at home. The plantations by their great demand for supplies offer a considerable local market. Secondly, though the workers on them have hitherto been immigrants, it is by no means certain that they will always be, especially as the standard of living on the estates rises. It may be expected, therefore, that there will not be the disinclination which there has been in the past on the part of the native Sinhalese to work as daily paid 'coolies' under a regimen which to him was servitude. In the old days the housing on the estates was not what it is to-day. Now in addition to excellent medical facilities and (in a few cases) to excellent co-operative stores, the housing itself of the labourers has been greatly improved. Thus the new lines which I saw on the estate of the English and Scottish Co-operative at Westhall, Kotmale district, Ceylon, are Government-standard huts made of cement, with concrete walls, iron frames, and verandas 6 ft. wide with a low wall in front, inside which the family can rest and play when it is too hot or too wet to be outside, while some yards away in the rear, and apart, are tidy latrines, also made of cement. Each room has its own chimney and fireplace, three or four inhabitants to the room. It must be remembered that the climate is such that much of the day throughout the year can be spent out of doors, while the nights are often so hot that many prefer to sleep in the veranda.

## 8. TEA CONTROL.

It is customary to use the leading cash crop of a country as the source from which funds are derived for purposes common to the growers concerned; and in addition the Government may add in this way to general revenue. In the Canadian wheat pools expenses were met by deductions from growers' receipts, and at any pool meeting or general agricultural conference it was frequent to hear suggestions that this or that desirable purpose could be thus financed. The planters of Ceylon have their Planters' Association, to which the members subscribe on an acreage basis. But the tea planters in addition pay a number of export taxes or

'cesses.' They amounted in April 1936, per 100 lb. of tea exported, to the following :

|  | Rs. | Cents. |
|--|-----|--------|
| <i>a.</i> Customs duty (taken to general revenues) . . . . . | 2   | 00     |
| <i>b.</i> Medical wants on estates . . . . .                 | 0   | 15     |
| <i>c.</i> Tea research . . . . .                             | 0   | 14     |
| <i>d.</i> Tea propaganda . . . . .                           | 0   | 75     |
| <i>e.</i> Tea control . . . . .                              | 0   | 11     |
|  | 3   | 15     |

The restriction scheme is more properly called a regulation scheme ; and it is concerned with the regulation of exports. In Ceylon it takes no account of domestic consumption, but in India it is accompanied at present by a gentleman's agreement under which producers agree not to manufacture for sale in the domestic market more than a certain percentage (in 1936, 12 per cent.) of the estate's basic crop. It does, however, in both countries, provide for a prohibition of new planting, save in special cases, and then only up to  $\frac{1}{2}$  of 1 per cent. of the total area under tea. Replanting is limited to replanting on the same area which has been uprooted, and the nursery acreage may not be increased permanently. The scheme came into force on April 1, 1933. There was a precedent for it in the post-war scheme of rubber restriction known as the Stevenson Scheme. The latter eventually failed, because in addition to being rather greedy and very inelastic it did not include the Dutch East Indies, where an enormous impetus was given to new production, especially by native producers. But this time Holland herself took the lead ; and the tea scheme of April 1, 1933, was followed by the new rubber scheme of June 1, 1934, Holland again being a member in respect of the Netherlands Indies. Inasmuch as the schemes in each country have the force of law, all producers must conform. Tea restriction has borne with exceptional severity on the activities of the English and Scottish Joint Co-operative Wholesale Society in South India. Since 1914 the English and Scottish Co-operative has added largely to its acreage, its policy being to produce as much as possible of its own consumption. What it already produces is a fraction only of this consumption. But now it cannot add to this except to a slight degree by the purchase of other producers' export rights.

Regulation was the final item in a long chapter of voluntary co-operation for other ends. The planters of Ceylon first came to co-operate closely with one another for the recruitment and regulation of labour and the organisation of medical services. Their next step was to co-operate for research. Before the war research was done in the Royal Botanical Gardens at Peradeniya, which in 1914 were transferred to the Department of Agriculture to serve as its technical nucleus. After the war the tea-planters began to feel that there was need of tea research by the planters themselves ; for the Agricultural Department now desired to pay more attention than before to the ordinary village agriculture of the island. A tea research scheme accordingly was drawn up, supported and financed by the tea industry and established by colonial ordinance. The Institute



was opened in 1926 and acquired its present habitation in 1929. This is the St. Coombs Estate.

Research hitherto called upon to assist expansion is now helping the difficult task of restriction. The supply of tea is not a tap that can be turned off and on at will. The produce cannot be left like tin or copper to lie in the ground until the market is better. But restriction being a fact, it must be carried through with the least financial and technical damage. A large company with numerous estates, some on high and some on low land, is in the better position. It will consider whether it is not better to close up one estate and put it down to 'care and maintenance,' allowing the other estates to work to capacity. A small company has less scope for this kind of rationalisation. It must decide whether it will (a) buy export coupons from others, so as to produce as much as before; (b) export only the higher grades of tea, putting the lower grades on the home market; (c) restrict production to its quota by discarding the poorer fields. But the home market is a small one and crowded with native small-holders, who are in the same case; while cutting out particular fields may bring a small company down to a production level which is well below the technical optimum. Therefore the Institute is engaged in working out the kind of reduction which is least harmful technically for estates in different situations.

The Export Control regulations are as follows :—

The International Tea Agreement fixes for each country a standard output. 'The standard upon which regulation is based shall be fixed on the maximum exports of tea from each producing country reached in any of the three years 1929, 1930 and 1931.' For each crop year the international committee sets a regulation figure, which so far has been at the following rates: 1933–34, 85 per cent. of standard exports; 1934–35, 87½ per cent. of standard exports; 1935–36, 82½ per cent. of standard exports. The reduction in 1934–35 was at the request of the tea trade, but it proved excessive and therefore the rate was raised by 5 points for the ensuing year.

It is the task of each country to assign to its own producers their individual share in the country's quota. Thus in Ceylon each estate is given export coupons for a certain quantity of tea based on past production as shown by the estate books. Native small-holders are allowed so many coupons per acre, inasmuch as they had no books showing their poundage. As the industry consisted in the main of companies possessing statistical records, the control scheme escaped the inaccuracies and 'overstatements' (for which it may or may not be possible to work out a 'coefficient of mendacity'), which obstructed the initial operations of production control in the tobacco industry of the United States.<sup>16</sup> The coupon is a quantity and not a quality coupon. The owner may export so many pounds weight of tea, not so much rupees' worth of value; and *pro tanto* the scheme favours quality production. But this has been neutralised by the recent increase of 2*d.* per lb. in the British import duty, which is expected to prejudice quality production by diverting British consumers to cheaper

<sup>16</sup> Cf. H. B. Rowe, *Tobacco under the A.A.A.* (Brookings Institution), 1935, pp. 164–181.



teas. In point of fact it is very customary for the small-holders to sell all their export rights, leaving their holding idle. There is a regular market for export coupons, as in the parallel rubber scheme.

On Monday, March 16, 1936, I attended the tea auction at Colombo. The great majority of the tea is sold with export rights attached; and prices ranged, according to quality, from about 60 cents per lb. upwards, but at the end of the auction some parcels of native tea were sold without export rights, and the prices were in the neighbourhood of 20 to 30 cents. This would be for tea of a lower quality than that which is exported. To give elasticity to the scheme it is allowable for a country or a company to carry over its quota from one crop year to the next.

The international authority is the International Tea Committee. From its two Reports, 1933-34 and 1934-35, it appears that the scheme has worked well and with but few changes. When nations mean a thing to work, there is no insuperable difficulty to international agreement. Loopholes have been stopped up. The Report of 1934-35 (pp. 16, 17) draws attention to the steps which have had to be taken to prevent tea smuggling across the overland frontier of India. Ceylon administers both the tea and rubber schemes in a single office under a single head, though in separate departments. The office is not a part of the Government secretariate, and is close to the harbour for the convenience of merchants. There has recently been introduced in Ceylon a coco-nut board, but this is not part of an export control scheme and there is no question of coupons. It is regulated by ordinance and has a central sales room for the display of coco-nut products; and its work is confined to the stimulation of the sale of these products at home and abroad and to the general encouragement of the coco-nut industry. The tea and rubber schemes, being international agreements, have a definite duration—tea to March 1938 and rubber to December 1938.

The reports of the International Tea Committee indicate satisfaction with results achieved to date. But the Committee is concerned with the danger of a decrease in consumption and has therefore instituted propaganda designed to expand the market. One small evidence of this is the shop on Colombo pier, where couponed tea can be purchased by passengers. Another is seen in the advertisement lighting along and around Colombo harbour. More serious is the campaign which has been launched in the United States to increase consumption there.

The British Empire is easily the largest producer of tea. Taking the figures for 1933-34, gross world exports amounted to 800 million lb.: from regulated countries 650 millions, from other countries (mainly China and Japan) 150 millions. Of the 650 million lb. 520 came from India and Ceylon, the proportionate export of the regulated countries being roughly India 3, Ceylon 2, the Netherlands East Indies  $1\frac{1}{2}$ . In rubber the British Empire is again the leading producer, though the contribution of India and Ceylon is trifling. The basic export quota of 1935 was for the whole world 1.1 million tons, of which Malaya was given 538,000, Netherlands Indies 400,000, Ceylon 79,000 tons. The Dutch have managed the control of native production by a heavy export duty on such produce, which is now being replaced by export licences such as

are required from the European planters. It must be remembered that in Sumatra, the leading producer of Netherlands Indies, much British and American capital is engaged.

In consumption of tea the British Empire again leads, for the United Kingdom and the Dominions consume respectively  $430 + 110 = 540$ , out of 860 million lb. consumed in 1933-34. But in consumption of rubber the position is different. A foreign non-producing country, the United States, consumes far more than the United Kingdom.

### 9. PLANTATION PRODUCE AND FORESTRY.

Plantation economy throws light on forest economy and *vice versa*. In the United States crop restriction, which in its first form was pronounced unconstitutional, is now being sought in indirect fashion by measures for soil conservation; and this involves afforestation, i.e. more forest produce. But the time when the produce will mature is so far ahead that no attention is being paid to the increase of timber which the policy will cause. In any case there is a fear of scarcity rather than of abundance; and forests are desired not only for their yield, but for the help which they give to the conservation of moisture and the like. 'And thus do we by indirections find directions out.'

In New Zealand there is conflict between two points of view. The public authorities (the Central Government and the municipalities) are concerned to conserve forests, protect water catchment areas and encourage native species where these will grow to advantage. The other point of view is represented by a commercial, and rather speculative, venture, which under the title of 'Perpetual Forests, Ltd.,' has planted large areas to a soft wood, *Pinus insignis*. It has financed itself by selling bonds not only in Australia and New Zealand but in many countries of the East; such bonds entitle the buyer to a share in a unit of the forest. Some of these plantations are now reaching maturity, and the problem has to be faced of how their physical increase is to be turned into cash by exploitation of the maturing timber. Asiatic holders, no doubt, would be glad to take the plot itself and build a bungalow on it, but the law against immigration forbids them to put their bodies inside.

Precious woods are at the other end of the scale. In Mysore State sandalwood is a government monopoly, and here there is a kind of restriction scheme which in principle resembles those for tea and rubber. The recent industrial depression spoilt the European market for sandalwood oil. The Government, which owns the wood and converts it into oil in its own factories, summoned the buyers and asked them how much they would take at or near the old price; and it has endeavoured to restrict sales to this amount. The difficulty is the competition of Australia, which produces more than twice the amount of Mysore and (in Mysore's opinion) has a much inferior product, improperly admitted recently to the British pharmacopœia. The technical problem involved in sandalwood restriction is this, that only dead wood is cut for treatment. The present restricted cutting leaves much dead wood in the forest, where it is liable to theft or damage. If cut and stored in the depot, there would

be heavy charges for storage and insurance. Madras has a little sandalwood, which is marketed by Mysore ; and Madras, apprehensive of the difficulties of restriction as at present operating, would prefer that sandalwood was sold up to the dead wood limit. It points out with reason that India is in fact making the market for Australia. There has therefore been recently an effort to associate Australia with the scheme ; for the lesson of rubber is that a scheme is likely to break down if it has outside it a formidable competitor.

In view of the high record of plantation economy in the nineteenth and twentieth centuries it is almost comical to remember that ' to send to the plantations ' signified in earlier days a sentence to penal servitude.



## SECTION G.—ENGINEERING.

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# THE ENGINEER AND THE NATION

ADDRESS BY

PROF. WILLIAM CRAMP, D.Sc., M.I.E.E.,

PRESIDENT OF THE SECTION.

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THE object of the British Association is to make known, as widely as possible, not only the aims and achievements of every science, but also the bearing of each advance upon world conditions. The very fact that engineering was the seventh section to be formed shows that there never was any intention to restrict the activities of the Association to 'pure' as distinct from 'applied' science. Our President was strictly in order when he suggested, last January, that Sectional Presidents should not hesitate to deal with current difficulties and misconceptions in their particular fields of work, and with the reactions of that work upon the community. These are matters that concern the engineer very closely, since his activity is linked with the national life and often consists in the application of knowledge previously secured by the physicist, chemist, and metallurgist. He himself is not thereby debarred from fundamental researches. On the contrary, he is frequently led to investigate in detail problems half solved by the physicist, or to discover phenomena which the chemist has missed. No better example could be quoted than the arc-rectifier, which from its humble beginning in the investigations of Cooper-Hewitt to its present position as the most important converter in heavy electrical engineering, is entirely the work of engineers.

### PURE SCIENCE AND ENGINEERING.

But though engineering has for so many years been regarded as a branch of science by the British Association, there are great and fundamental differences between those engaged in pure science and the engineers. The former may, if they so choose, indulge in a life of ardent detached curiosity, devoting themselves to the observation of behaviour and to the construction of a framework of principles neatly fitting the collected observations. To such men, the known is just a key to the unknown, and the unknown is the one thing worth knowing. This is called the pursuit of truth as distinct from the pursuit of learning. Around each hypothesis, prediction becomes possible; but should new results be incompatible with previous theory, the worker does not hesitate to alter his construction to accommodate the fresh knowledge. Such a life brings great happiness, since it entails self-forgetfulness, the satisfaction

of curiosity, the exercise of reason and the joy of constructiveness and of wonder. When pursued under the best conditions, it is as free from worldly care and responsibility as was that of the mediæval monk, and for that very reason it is apt to be incomplete and ill-balanced. Such self-forgetfulness is not true freedom from ego-consciousness, since it is only temporary. It is not altruism. But the blissful dream-life of the laboratory may easily become as entrancing as the paradise of the opium addict. The man of science is happily almost free from the jealousy and exhibitionism which afflict the artist, but his joyous Nirvana may make him oblivious of others, and his interest in things may obscure his interest in persons. As I have said elsewhere, it is probable that Mrs. Faraday spent too many lonely evenings in the garret of the Royal Institution <sup>1</sup>—and even the university professor, whose human interest should be sustained by daily contact with students, may fall a victim to the dope of research. Thus, a certain French professor, when asked how many students he had, replied: ‘as few as possible; I find that they interrupt my work.’

The function of the engineer is to apply the co-ordinated knowledge of the pure scientist and the experience of the ages to the satisfaction of human desire, and to the increase of the amenities of life. He is the link between human experience and scientific knowledge, and, as such, he cannot perpetually live in a rarefied atmosphere of detachment. He must be in daily contact with humanity and learn to understand human psychology as well as human needs. As a result, he is less specialised, more balanced, more adaptable and understanding than his colleague in pure science. His judgment in human affairs is more developed; he is a better ‘mixer.’ A nation of pure investigators would be calm and peaceful, but cold as Scotland Yard. A nation of engineers might be quite a pleasant community.

#### ENGINEERING AND CIVILISATION.

In its purest form, engineering is the greatest instrument of civilisation that the world has ever seen, in the sense that it continually tends to promote a closer contact, a greater intimacy, and therefore a more profound understanding between individuals and nations. Three-fourths of the work of the engineer is devoted to the development of communication. Roads, canals, bridges, railways, harbours, ships, motor-cars, aeroplanes, telegraphs, telephones, television, all these and many more are humanity’s hyphens. Their natural effect is to foster friendliness and dissolve differences. Left undisturbed by the politician, the scaremonger, and the patriot, the engineer would demolish the Tower of Babel and render war impossible. Build a channel tunnel; then Calais and Dover become neighbours and Anglo-French understanding ensues in all senses. Place transmitters in the trenches with receivers and televisions at home; then war becomes unthinkable. The very first thing that a government does on going to war is to seize and control every means of communication and every engineering device that might otherwise serve to unite the

<sup>1</sup> *Faraday and Some of His Contemporaries* (Pitman & Co.), pp. 60, 61.

combatants. Then ensues that apotheosis of wicked absurdity which was to be seen in Switzerland during the Great War. A works normally devoted to machinery for the preparation of cereals, consisted of two long bays. Up and down one bay went the inspectors of the Central Powers, checking the production of their shells. Up and down the other bay walked the inspectors of the Allies on similar work for their countrymen. And this ironical madness still exists; for only a few weeks ago I received a letter from an old student, which contains the following sentence: 'The torpedo works where I am at present working is very busy. We are producing these instruments of war for most of the European nations, and, as far as I can gather, the works will be up to full capacity for several years.' Verily for the promotion of peace and understanding, engineering easily outclasses every religion; and for battle, murder, and sudden death it has no equal.

#### STATUS OF THE ENGINEER.

To each nation then, as well as to the world, the activities of the engineer, and the uses to which they are put, are matters of supreme importance. His position in peace and war is very different from that of the devotee of pure science. True, great physicists and great chemists may be called upon in times of emergency, but they then renounce their ordinary occupation to take up employment akin to the normal work of the engineer. At all times, in peace or in war, the engineer must be intimately concerned with human relationships. This fact gives him proportionately greater opportunities both for the development and for the loss of character: his chances of salvation and of damnation are alike increased. For character does not mature in cloisters and exposure is necessary to prove immunity.

To what extent do his fellow subjects recognise this national importance and this difficult dual rôle; and to what extent does the engineer abuse his unique position or allow himself to be made the tool of less scrupulous men? In short, what attitude does this nation adopt towards the engineer, and how does the engineer respond?

In any community, the status of an individual should depend upon the extent to which his occupation is fiduciary, upon the measure of responsibility which he incurs, and the nature of the services he renders. The doctor is held in esteem largely because his patients are dependent upon his honour and good faith, as well as upon his knowledge and skill. He is in a position of trust as well as of responsibility, and his conduct is expected to be unaffected by the lure of private gain. His motto is, or should be, *noblesse oblige*, not *caveat emptor*. On these assumptions, the status accorded to him is deservedly high. It is nationally defined by the General Medical Council and jealously guarded by the British Medical Association and the legal insurance societies. The present period of training for a general practitioner is six to seven years from matriculation. At the end of that time, he steps straight into a great profession with a tradition of noble service and unhesitating devotion to duty. The protection afforded him is proportionately great. He may



make technical blunders in diagnosis or in treatment, involving even death, or he may neglect panel patients ; but neither patient nor relative dare move against him for fear of the professional organisation of which he is now a part. On the other hand, except in extreme cases, he knows that his colleagues will view mercifully any untoward 'accidents,' and his certificate of death will rarely be questioned.

Fortunately, the great majority of the medical profession are men whose lives are beyond reproach, but that this protection may sometimes go too far is shown in the following instance. A relation of mine died in the nursing home of a well-known surgeon. I discovered afterwards that this surgeon had for some time been addicted to the drug habit. It had such a hold upon him that even in the operating theatre he would slip behind a screen to give himself an injection. Such a weakness could not be unknown to the doctors and nurses ; and indeed it was a nurse who first told me and a doctor who confirmed the statement. Notwithstanding this common knowledge, no action was taken, and for at least five years after the events mentioned this surgeon continued to practise. Ultimately, of course, his brain was affected, and he died in a mental home.

Contrast this with the position of the engineer. His training also takes about six years from matriculation, but he then has no status that is nationally recognised. Yet he is held to be legally and financially responsible if he fails to apply such knowledge as is in keeping with the 'state of the art,' and he has no legal assistance from his professional Institution when he is attacked. The example of the Johannesburg engines aptly illustrates this point, but there are many instances of far less importance where the courts have held the engineer responsible. I remember a case in which, under exceptional circumstances, an iron staircase collapsed, and the engineer was held liable for the faulty design or material of the brackets that supported it.

The fact is that, as the years pass, even at home, each one of us becomes more and more dependent upon the skill, knowledge, and good faith of the engineer. Three simple examples will illustrate this point.

(i) Gas authorities all over the country are at present actively pushing the use of the gas-cooker on which the engineer has provided an outlet for a flue connection. Even where stoves are installed by a municipal authority, it is rare to find this outlet connected to a chimney or flue. Consequently, all the products of combustion and cooking pour into the room until the air of a small kitchen becomes foul, and acid-laden moisture runs down the walls. In this instance it is usually the commercial man who is to blame. The engineer is not allowed to control what is obviously an engineering matter.

(ii) Coke is sent to many houses for central heating, etc. It is often delivered with 20 per cent. of water in it. Suppose that the price of coke is 30s. per ton. Then for every twenty tons of coke ordered, the salesman delivers sixteen tons of coke and four of water. Dirty water at 30s. per ton is dear. It is said that the water is due to the quenching of the coke as it leaves the retorts, and therefore the engineer is to blame. That, of course, is no excuse. The engineer would be quite willing to dry the coke, or alternatively, to declare the moisture content, so that a

proper allowance could be made. This, however, would not suit the salesman, and so we have a new form of an old rhyme :—

‘ Little drops of water in a bag of coke  
Fill the gas-works coffers. Good then ; let it soak ! ’

The engineer, moreover, knows that this is not the end of the mischief. He is aware that part of the heat of the coke must be used in evaporating the water bought at 30s. per ton.

(iii) I lately had an electric kettle installed. I insisted that it should have a three-pin plug and be properly earthed. The contractor carried out my instructions, but told me that he was constantly putting in such apparatus yet never took this precaution unless the householder insisted. This is an instance where the Institution is quite definite in its rules, but is without the power to enforce them. I need not remind members of this Association of the unfortunate deaths due to such neglect.

It may be objected that this contrast is unfair, since the responsibility of the engineer is far less than that of the doctor. But is it so ? Three-quarters of a doctor's daily work consists in visiting and prescribing for routine cases, where nothing more than ‘ *pulv rhei et sac alb* ’ or their equivalents are needed. When serious matters arise, the modern practitioner often sends his patient to the specialist. The responsibility of the engineer even in so simple a thing as house-wiring is far greater ; and when such matters as the design of high-speed machinery, the brakes and steering gear of a motor-car, or the stability of a structure are considered, there is no comparison at all. Where the doctor's neglect kills one man, the engineer's mistake may kill 100. But the doctor can bury his accident behind a death-certificate which he himself issues, while the engineer must submit to a public legal inquiry. The loss of prestige attaching to faulty design or workmanship after such an inquiry, constantly urges the engineer towards greater and greater care, and this in the last resort is the safeguard upon which the nation relies. Such a liability will serve as the best antidote to an abuse of privilege, but it can only be justified as the concomitant of recognised status. The engineer now has the liability without the status. The doctor or barrister has fairly acquired the status ; but the organisation to which he belongs tends, as I think unwisely, to shield him from the healthy breeze of liability.

#### REMUNERATION OF THE ENGINEER.

As regards remuneration, the contrast between the engineer and the members of other professions is equally striking. A medical man just qualified is admitted to His Majesty's forces at a salary of £387 per annum for a period of five years, and if he then leaves the service he receives a gratuity of £1,000. Thus at the age of say 26, he is regarded as being worth nearly £600 per annum. If the same man accepts work as a ‘ locum,’ he will demand as a minimum £10. 10s. per week, with free accommodation and the use of a motor-car. It is not difficult for a youngster who is not too scrupulous to reach an income of £1,000



per annum by means of panel work within three years of putting up his plate.

The corresponding pay of an engineer at the end of his training is £200 per annum, and after a further three years he is lucky if he reaches £400. I have known engineers responsible for the design of high-speed turbo-generators whose remuneration never exceeded £750 per annum.

It is appropriate here to point out that the high pay of the young doctor has a reaction upon the progress of medical research. Every university has a certain number of post-graduate scholarships to offer of about £100 per annum. An engineer will willingly accept one of these for the sake of training in research, though it often entails a considerable sacrifice. As a rule, the medical student will not consider them at all. He asks for £250 to £350 per annum if he is to take up research, and for such scholarships no funds are available. Consequently, the output of original work from the medical schools is small compared with other branches of pure and applied science.

#### CHARGES AGAINST THE ENGINEER.

The conclusions to be drawn from this analysis will be mentioned later. It is necessary to point out that, besides the responsible work which he undertakes and the legal liabilities to which he is exposed, the engineer is called upon to answer certain charges laid against him by the preacher and the press. The first is that he is equally willing to lend himself to works of utility and to works of death and destruction. Remember, however, his dual rôle. Pure science has nothing to do with ethics; she recognises no moral obligations whatsoever. The same explosive that releases coal underground can also kill men in battle. The telephone is useful alike in the home and in the front line trenches. The same bacteria may be beneficial in one case, harmful in another. The same principles that bring the stars within our ken also control the range-finder. There is no scientific apparatus that cannot be misapplied; and to every advantage there is a corresponding drawback. The ear that relishes music is the more sensitive to discordant noise. Not until beauty is seen to be beautiful can ugliness be defined. To the extent that the engineer is a scientist, the use to which his discoveries shall be put does not concern him. But, it will be urged, the engineer on the human and commercial side designs and makes armaments for profit. And if he does, shall he not be credited with at least as much honesty of purpose as the politician who declares war and orders the guns? May he not be persuaded, profits apart, like the Archbishop of York, that 'the great war was a thousand times worth while'? These are matters that have nothing to do with engineering *per se*, but with Man—the embodiment of creed and conscience. The engineer is in such matters exactly on a par with the rest of mankind.

Again, the engineer is charged with some responsibility for the existing



economic chaos. 'There should be a moratorium as regards scientific research and development,' said one preacher to the British Association. 'The world would have been a better place if the internal combustion engine had not been invented,' said another. 'If it were not for the immense increase of automatic machines and of labour-saving devices, we should not have the problem of unemployment,' says the press. True enough, we should not. But the invention of a machine does not compel the use thereof. Let him who holds these views, return home, smash his lawn-mower and his wife's sewing-machine, and engage gardeners to cut the grass with shears, and seamstresses to hem by hand the household sheets. To rid the world of machines needs a change of attitude towards occupation, a love of monotonous work for its own sake, a real desire for real work and not merely for the reward thereof. *Que messieurs les assassins commencent !*

Yet another view was often urged during the period of blackest depression, and still is sometimes heard : 'If our inventors were more fertile and our engineers more enterprising,' it is said, 'they could introduce new industries in the distressed areas.' But the man who writes thus can have little knowledge of the real facts. It is not merely that the Englishman is essentially cautious and conservative, nor that the inventor is unduly optimistic—though these things are true enough. The whole legal system in this country is framed in such a way as to thwart the inventor who would create a new industry. Generally, the only way to proceed is by taking out a patent. This is of no use unless pirates can be restrained. To defend a patent, or to attack an alleged infringement, involves incredible legal expense ; and large firms, knowing this, will unblushingly copy an invention, relying on the inability of the patentee to finance an attack. The Patent Office, having granted the letters patent, takes no further interest. Let me give an illustration of the course of a patent action from my own experience. 'A' sued 'B' for infringement. Each party immediately promised to indemnify his users against a demand for royalties if he lost. In the first court, after three weeks' hearing, 'A' lost. The case went to appeal and 'B' lost. 'A's Counsel, coming from court after the appeal, happened to meet the judge of the former trial. The judge asked how the appeal had gone. 'Your judgment was reversed, my Lord,' was the reply. 'Ah,' said the judge, 'I thought it might be ; I could hardly understand a word about it !' 'B' could not afford to carry the case to the Lords and, in fact, went bankrupt, so that his users received no protection from the indemnity. The case cost in all £30,000 ; more than half of which was incurred in trying to get a decision before a judge who admitted that he could not understand the technicalities. The costs were swollen by Counsel, who pressed for Juniors and introduced side-issues, which, I thought, lengthened the hearing unnecessarily, and thus entailed too many 'refreshers.' There is no hope for the patentee in this country under such a clumsy, ineffective system ; but to change it will be difficult. It will be necessary to break through the resistance of a thoroughly case-hardened Bar, and engineers know what that means. I believe that this Association is the only body with the necessary prestige

and influence to produce the desired effect. I hope that this Section will urge the Council to take steps to bring about a reform that is so long overdue.

In France, thanks largely to Napoleon's short way with legal privilege, the case given above, with an appeal, cost less than one-tenth of the hearing in the English courts. There, to the best of my recollection, the system is as follows. The courts sits to determine if there is a case. Having decided in the affirmative, three technical experts are appointed, one by each litigant and one by the judge. These three have access to all apparatus, experiments and documents. Each presents an independent report to the judge, and on these the issue is decided.

As a further example of these ills, I remember an opinion being sought upon a point of patent law. The barrister did not answer for three weeks and the matter became urgent. A director of the firm who had sent the inquiry, met the barrister by chance near Lincoln's Inn and reminded him of the case. Counsel said 'Let's see; what was it about? Have you the papers here?' The director produced a copy of the letter. The man of law, standing on the pavement, scanned the document hastily and said 'I should say "No,"' and hurried away. Next week the firm received a bill for forty guineas for this 'opinion.' No legal redress seemed possible; for the directors were told by their solicitor that if they refused payment, no barrister would in future act for them.

But it is not only in the law-courts that invention is penalised. In Government Departments and in some large firms the decision to adopt or to reject a new idea (as well as the reward to the inventor) is too often in the hands of men whose opinion on the subject is worth nothing: financiers, accountants, lawyers and men with no scientific training. Many firms expect all new ideas to emanate from their own staff. If advised by their technical men to take up a particular invention, they will almost invariably reply 'Can't you get round it?'—which is an incitement to dishonesty difficult to withstand, but made easier to accomplish by the legal system already described. As an example of Government Departments, the Board of Admiralty at once comes to mind. This body has many technical matters to decide; yet it is entirely composed of admirals and politicians, an arrangement which, at the time that Board was formed, was no doubt sound; but is it not now an anachronism?

#### ATTITUDE OF THE ENGINEER TOWARDS THE NATION.

Having thus roughly observed the attitude of the nation towards the engineer, we may cross the road and look at the matter from the other side. Here I know that I am on difficult ground; for the engineering departments of universities are much beholden to their colleagues in industry and gratefully acknowledge the many courtesies and great help which they receive so often. At the same time, I know my professional brethren too well to think that they will resent comments born of experience, especially when my sole object is to obtain for the engineer that recognition of which he is at present deprived. The question at issue is that of professional



conduct ; and it is made all the more difficult by the commercial conditions from which the engineer cannot altogether escape. Curiously enough, this 'honourable behaviour,' 'scale of values,' call it what you will, seems to be an attribute of the round soul of the man and almost independent of home influence or educational environment. 'Things 'not done' when wearing the old school tie, seem to be regarded as permissible in after life. Consider the following instances :

A man, whom I will call Smith, was brought up in a wealthy and cultured home, sent to a renowned public school and then took his degree in the Mechanical Sciences Tripos at Cambridge. He next entered the large engineering business created by his father, where he soon became managing director. A contract for a building and equipment in which the local town council was financially interested was to be placed, and it was known that there were only three firms in the country, 'A,' 'B,' and 'C,' who could supply the machines required. Of these 'A' was controlled by Smith, 'B' was equally capable and controlled by a friend of Smith's, and 'C' was of minor importance. It was agreed between Smith and his friend that each should include in his tender a sum of £1,000 to be paid by the winner to the loser. Firm 'A' obtained the order, and the private account of Smith was credited by his firm with £1,000, that he might send his private cheque to his friend, who presumably paid a like amount into the account of 'B.' As an ironical corollary, Smith later became mayor of the very town whose contract had been tampered with in this way.

It may be argued that co-operation of this kind to repay a firm for the cost of getting out an unsuccessful tender is justifiable. I should agree if it were done openly and recognised. But the very secrecy surrounding the cheque suggests in this instance that both Smith and his friend were really ashamed of the transaction.

My second example concerns an engineer of similar standing who had secured a large order for a complete plant. His customer asked him to advise on the selection of engines and boilers. He agreed to act as consulting engineer for a fee of 5 per cent. on the cost of the power plant. When the tenders came in, however, he passed over the best offer in favour of a maker who would reserve for him a further 5 per cent. This commission was not, of course, divulged to the purchaser. Subsequently, this same man took a similar secret commission on a building in South America, and the invoices for the machinery were falsified to avoid customs dues.

Another form of temptation which assails the engineer because of the dual nature of his work is illustrated by the following example :

A firm of engineers whose directors had learnt the value of scientific investigation through their university training, embarked upon a series of tests. The object was to find out whether the machines that they made were capable of a greater output without an inordinate increase of power. It was proved conclusively that by increasing the speed about 20 per cent. the output went up proportionately, while the power was only raised by about 5 per cent. Further tests showed that there was in each case a



'most efficient speed,' which was considerably higher than that recommended in their catalogue. Those results have never been, and I suppose never will be, published. The catalogue speeds have not been changed. For it was evident that, if the customers once realised the facts, no extensions of their works would be needed for some time.

In none of these examples were the engineers in need of money. In the first two, the standard of values that should have been absorbed at home, school, and college was abandoned for an increase of income that was trifling. In the third case, the university had inculcated a spirit of scientific inquiry, but the firm would not sacrifice private profit to the advancement of science. In all three cases, the serious consequence is that once a man slips so far, he is ripe to take his part in questionable collective action. A small blot on a single page may soak through the leaves of a large volume.

#### ENGINEERING ASSOCIATIONS.

It is an aphorism of political life that trusts and combines grow well in the shelter of tariff walls, and the protection afforded to various sections of the Engineering industry by the war and since 1918 has certainly confirmed this dictum. Cement, tubes, steel, cables, instruments, electric lamps and, to some extent, electric motors, are now controlled by Associations of manufacturers, of which probably the Cable Makers' Association and the Electric Lamp Manufacturers' Association are the most powerful. The purchaser may not now buy where he likes, nor is there any competition to regulate prices automatically. The individual firms have little control over prices, and I have known instances where goods ordered from one firm have been supplied by another without the courtesy of a reference to the purchaser's wishes.

The avowed object of these Associations is to standardise and to maintain the quality of the goods, and to eliminate unnecessary duplication of administrative work, wasteful tendering and unfair price-cutting. It is asserted that such co-operation must benefit the buyer by reducing overhead charges, thus enabling the maker to supply as good an article at a lower price, with a fair margin for research, for development, and for profit.

It may be argued that such organisations are the work of financiers and commercial men, and have nothing to do with engineering. But that is not always true; for in some instances engineers are largely responsible both for their formation and management; and where it is true, the engineer suffers from their mistakes. The subject also has a special interest for this Association, since in his Presidential Address to Section G at York, Professor Miles Walker insisted that a cure for the present economic chaos could be found in a world governed by engineers. The Associations are a test of that theory.

It will be agreed that the objects in view (as expressed above) are both laudable and logical, but it is fair to ask whether those objects are in fact achieved without detriment to the community as a whole. In two

instances at least (viz. cables and lamps), the Associations have thoroughly established and well maintained the quality of their wares, and the trading profit has been such as to enable the makers to spend very large sums upon development and research, and to support generously such undertakings as the Electrical Research Association. That the profits are at least adequate is shown not only by the large sums placed to reserve, but also by the declared dividends and the market price of the shares. This is illustrated by the following table relating to four leading cable companies. The prices are for July 1936.

| Firm | Share Denomination | Last Dividend                   | Market Price of Share |
|------|--------------------|---------------------------------|-----------------------|
| A    | Ordinary £1        | 15 per cent.<br>excluding bonus | £5 7s. 6d.            |
| B    | do. do.            | 15 per cent.                    | £4 2s. 6d.            |
| C    | do. do.            | 15 per cent.<br>excluding bonus | £7 7s. 6d.            |
| D    | do. do.            | 25 per cent.                    | £5 5s. 0d.            |

From these results, it might be argued that the Association had achieved rather more than its object in one direction, and had not yet begun to pass on the benefit to the buyer. This view is emphasised by the fact that most electrical firms ardently support the Electrical Development Association, whose aim is the furtherance of every application of electricity. It is clearly difficult to strike a balance between the desire to achieve those ends and the opportunity to benefit by the elimination of competition and the helplessness of the buyer, who has no remedy but by a question in the House of Commons.

There is, however, another side to the activities of some of these Associations, which from the national point of view is perhaps more disquieting. I mean the discrimination against the home market in favour of the foreigner. In some instances, it is theoretically possible for an agent abroad to import British goods, re-export them to Britain and sell them there at a good profit against similar goods that have not made the double journey. I heard of an Egyptian who played this cunning game until his supplies were stopped. What offence has the poor Briton committed that he should be so heavily penalised by his compatriots? Heaven forbid that I should do anything to fan the flame of economic nationalism, but it does seem reasonable to ask that an Englishman at home should be allowed to buy from an English firm at as low a price as a foreigner abroad. Do not manufacturers always owe something to the country in which their industry is carried on, and will they not in return resist the temptation to squeeze the inhabitants of the very state which, by its protective tariffs, has rendered their monopoly possible?

It is certain that no trade combine can continue to operate unchecked in England, unless informed with a spirit of reasonableness that is self-commending. There is nothing that the Englishman hates more than misused private power. He would not have it from King, Barons or Church; and if he once believes that he is being driven by a trade organisation, he will insist either upon state interference or a democratic constitution for the offending body. The only tyranny to which he will submit is one that is self-imposed, because he thinks that it can be ended when he pleases. It is certainly desirable that those who direct the activities of trade associations should be well acquainted with '1066 and all that.'

It would be very unjust if any of these comments were regarded as applicable to the Electrical Research Association. That body only concerns itself with large scale investigations of electrical engineering problems. It has nothing to do with sales or prices. It has carried out, and honestly published, a vast amount of original work at a great cost to the industry and a very small cost to the nation. The 'Buried Cables' Report alone has saved the nation literally thousands of pounds, and England is exceedingly fortunate in having a voluntary body working so consistently in the public interest. It is a strange psychological phenomenon that some of those engineers who loyally aid this beneficent organisation are also among the supporters of Trade Associations pursuing a different policy.

### CONCLUSIONS.

This brief investigation of the relations between the engineer and the nation points to the necessity for certain reforms. Of these, the first is the provision of some body with statutory powers to define the qualifications and status of those who may use the title Civil Engineer, Mechanical Engineer, Electrical Engineer, etc., to prevent unqualified persons from jeopardising life and to check unprofessional conduct. At present, the three great Institutions try to fulfil that rôle, and the Institution of Consulting Engineers has also done its best. But as none of these bodies has statutory powers, the rules that they frame cannot be enforced. The late Professor S. P. Thompson told me that when he was President of the Institution of Electrical Engineers, he found it his duty to call the attention of a certain member to flagrant breaches of the professional code. The member did not reply but continued his naughty conduct. Dr. Thompson then tried to make his protest libellous by repeating the charges on a post-card. To this he received the following answer:— 'Dear Prof. Thompson, I think it is now time that this correspondence ceased. Yours, etc. . . .' In the face of such bravado, what can one do? The answer is that, by means of an organisation that has grown up in one generation, the medical fraternity has progressively improved the standard of qualification, and has earned the nation's gratitude by getting rid of humbugs, charlatans and quacks. The engineer asks for a similar recognition and a like opportunity. But the medical profession and the Bar have also



achieved a measure of immunity from liability for which the engineer does *not* ask ; believing that therein temptation may be lurking amid the slime of self-interest.

The second reform is the proper representation of science upon all governing bodies in industry, and upon all technical departments in the state. Here I think this Association can do the nation a service by passing a resolution asking for more adequate representation on the Board of Admiralty and similar state bodies. I should like to see a small Committee of this Section appointed at this meeting to explore the matter further.

A third reform, dependent to some extent upon the first and second, is some machinery which in technical matters will prevent the engineer from being over-ruled by the commercial man. This is a very difficult subject ; but at least a beginning could be made with government and municipal undertakings, where the evil is very pronounced. The three examples on pp. 144-145 illustrate this point exactly. It is not right that the citizen should run risks of life or health to save trouble or expense to a trading department. The county and borough councils have the remedy in their own hands. On engineering questions the engineer should always have the last word.

The fourth reform is a drastic alteration of the patent procedure in the law courts. Here, again, I think this Association should help by recognising the existence of this evil and recommending that a Royal Commission be appointed to investigate the subject at once.

The fifth reform concerns the Trade Associations and can only take the shape of a suggestion. To obviate unpleasant suspicions, and to enable these bodies still to carry on that part of their work which is so beneficial to the nation, I would most strongly advise them to make their Councils fully representative of all the three interests, viz. : makers, contractors, and buyers. I think that if they fail to do this, they will slide by degrees into a slough of self-interest, until questions in the House of Commons, or the advent of a Socialist Government, leads to state interference with their organisations.

Finally, there is the question of the general professional code of the engineer, as illustrated in the examples on pp. 146 and 147. Everything possible under existing conditions had been done to give those sinners a high code of honour, and yet they failed to respond. The only conclusion possible is that the existing conditions of training are lacking in some essential factor. The modern curriculum both in school and university has become so crowded, the teaching so vocational, and the objects so material, that a real perspective of life is impossible. Youths and maidens sail away from the university with excellent intellectual training, but with no sheet anchor to which they can trust in distress. This is true of every faculty : of arts as well as of science and medicine. The result is that when they meet a strong current of self-interest, they drift helplessly, and we see them exhibiting that unsocial behaviour of which I have given so many instances. The remedy lies in the hands of parents and of those who control educational institutions : it is urgent and of national

importance. I commend its consideration to the Board of Education, the Committee of Vice-Chancellors, and to the members of Section L. British engineers have, in the past, earned a great reputation for reliability and straight-dealing. This is a national asset of real value ; which can only be maintained if, as in our national games, we continually place integrity before personal advantage.

## SECTION H.—ANTHROPOLOGY.

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# THE UPPER PALÆOLITHIC IN THE LIGHT OF RECENT DISCOVERY

ADDRESS BY

MISS D. A. E. GARROD,

PRESIDENT OF THE SECTION.

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THE last twelve years have seen a new impetus given to prehistoric studies by the multiplication of researches outside Europe. Excavations in Africa, the Near East, Asiatic Russia and China have opened up a new field for speculation, and at the same time have revealed the unsuspected complexity of many problems which to De Mortillet and other pioneers seemed relatively simple. Gone for ever is the straightforward succession of Palæolithic cultures from Chellian to Magdalenian as laid down in the Musée Préhistorique. Even as early as 1912, when Breuil produced his classic paper on the subdivisions of the Upper Palæolithic its foundations were sapped, and the discoveries of the last decade have merely completed its demolition as a system of world-wide application.

I need not insist that De Mortillet's scheme, as corrected by Breuil, who first pointed out the true position of the Aurignacian in western Europe, was the best that could be devised given the very incomplete information, relating to a very limited area, possessed by workers at that date. The fault of De Mortillet's disciples lay in their canonisation of a system which could only be applied locally, and which in any case contained enormous gaps. The attempt to bring into this framework the first discoveries made outside Europe inevitably led in many cases to forcing of the evidence, and it was not until the old orthodoxy had been dethroned that the new material could be made to give its full measure.

In the old system the Palæolithic cultures appeared as a straightforward succession with clear-cut horizontal divisions, as in a diagrammatic geological section. For the Fathers of Prehistory these cultures developed logically one from the other in an orderly upward movement, and it was assumed that they represented world-wide stages in the history of human progress. To-day prehistory has suffered the fate of so many of the component parts of the orderly Universe of the nineteenth century. New knowledge has given a twist to the kaleidoscope, and the pieces are still falling about before our bewildered eyes. The main outline of the new pattern is, however, already beginning to appear. We can distinguish in the Old Stone Age three cultural elements of primary importance. These are manifested in the so-called hand-axe industries, flake industries and blade industries, and we know that the first two, at any rate, run side



by side as far back as we can see, and we are beginning to realise that the origins of the third may have to be sought much farther back than we had suspected. Only a moment of reflection is needed to see that we have here the old divisions of Lower, Middle and Upper Palæolithic, but with a new axis. The diagram has been manipulated like one of those patterns which oculists twirl before the eyes of astigmatic patients, so that not only have the horizontal lines become vertical, but, as to the astigmatic eye, the divisions which were formerly so clearcut are now blurred. I want to insist on this blurring, because in the ardour of conversion some prehistorians are tending to make the new vertical divisions as rigid as the old horizontal ones. In fact these culture-streams do not run parallel and independent; such a view of human history would be absurdly artificial. They are perpetually meeting and influencing each other, and sometimes they merge to produce a new facies.

In the creation of this new outlook (as in so much else) it would be difficult to overestimate our debt to the Abbé Breuil. I think it is true to say that he was the first prehistorian to develop a genuine world-outlook, and his investigation and correlation of a mass of evidence from widely-separated areas has led directly to that change of axis which to-day we are beginning to take for granted.

In the attempt to present in an intelligible form our new vision of man's earliest history we are hampered by a vocabulary which is out of date. In his monumental *Weltgeschichte der Steinzeit* Menghin has recently attempted to produce a terminology which will meet the situation, but although this remarkable book contains ideas which are interesting and utilisable, it is open to criticism on several grounds. Instead of using the general division into hand-axe, flake and blade cultures which undoubtedly gives the best results when we are dealing with the Old Stone Age, Menghin treats flake and blade cultures as one, and creates a third class for bone cultures. That his framework is in fact artificial and far too rigid is proved by the fact that it leads him into a number of contradictions, as when he classifies Predmost as a hand-axe culture on account of the presence of primitive Solutrian types, and then is obliged to bring the pure blade culture of Mezin into the hand-axe class because its art is so clearly related to that of Predmost. He fails also in dealing with one of the chief difficulties of the old system, which is that the terms Lower, Middle and Upper Palæolithic are used at the same time in a chronological and a typological sense. At the time when the system was created this was quite logical, but it cannot be made to work to-day. Nevertheless we seem unable at the moment to get free from this entanglement, and nine prehistorians out of ten continue to use these terms as more or less synonymous with hand-axe, flake and blade industries respectively. Menghin attempts to meet this by re-baptising the Lower and Middle Palæolithic as Protolithic, and the Upper Palæolithic and Mesolithic as Miolithic, and assigning to each its own groups of hand-axe, flake and bone cultures, but he thereby perpetuates the idea of a discontinuity between the Protolithic and Miolithic, an idea which we are coming more and more clearly to see is contradicted by the evidence. Moreover, by using the terms Epiprotolithic and Epimiolithic for industries which are of

Protolithic and Miolithic type respectively, but later in time, he betrays that he has not freed these terms of typological significance. The time has come when the labels Lower, Middle and Upper Palæolithic should be used exclusively in a chronological sense, without any typological connotation whatsoever, to cover approximately the periods from the beginning of the Pleistocene to the end of the Riss Glacial, from the end of the Riss to the middle of the Würm, and from the middle of the Würm to the close of the Pleistocene respectively. For purposes of typological classification the three main groups of hand-axe, flake and blade cultures are essential, but should not be made too rigid, and it will be necessary to multiply names derived from type-stations to denote the many variations found within these groups. Here again, however, a warning seems to be needed, for there is a tendency to-day unnecessarily to create distinct labels for industries which are essentially the same, though found in widely separated areas, and this practice tends to obscure those migrations of culture over wide areas which it should be our major interest to trace and interpret.

These general considerations are necessary to clear the ground for the subject with which I am going to deal—those cultures whose appearance in Europe towards the close of the Pleistocene marks the extinction of Neanderthal man and the arrival of *Homo sapiens*. In the main these are essentially blade cultures, though in certain areas industries of Mousterian tradition lingered on into Upper Palæolithic times. Now it is clear that these blade cultures must have passed through the early stages of their development somewhere outside Europe, during Middle or even Lower Palæolithic times, but we have at present only the faintest clues as to how and where that development took place. In dealing with them we are therefore in fact dealing mainly with that period which we have defined as Upper Palæolithic, but we should bear clearly in mind that this limitation is due only to a limitation of our knowledge, and should guard against falling into the error of applying the term Upper Palæolithic to the industries themselves.

Before showing how recent discovery has modified and enlarged our views on this subject it will be necessary to give an outline of the situation as it stood roughly twelve years ago. In western Europe, at any rate, the succession of blade cultures was pretty clear. We had the Lower Aurignacian with its curved points, the Audi stage followed by the Chatelperron stage; the various levels of the Middle Aurignacian, with keeled and nose-scrapers and notched blades; the Upper Aurignacian, subdivided into the Gravette and Font-Robert stages; the Lower, Middle and Upper Solutrian; and finally the six stages of the Magdalenian. Outside Europe the only blade industry which had been studied at all seriously was the Capsian of North Africa, and this was regarded as the parent of the Aurignacian, the generally accepted view being that the Lower and Upper Aurignacian represented successive Capsian invasions of Europe, while the Middle Aurignacian developed *in situ* at a time when contact with Africa was temporarily broken. The Solutrian was recognised as an intrusion from central Europe, the special form which it assumed in the West being due to contact with the Upper Aurignacian



already in possession. Finally, the Magdalenian was regarded as a highly specialised local development of the Aurignacian, though the possibility of Eastern influence was not excluded.

It was recognised that central and eastern Europe presented certain peculiarities. In particular the Upper Aurignacian of Moravia, as represented in the great loess station of Predmost, contained a remarkable range of objects made of bone and mammoth ivory, ornamented with geometric designs of a type unknown in the West. A Solutrian of a primitive kind, unmixed with Aurignacian forms, had been found in the caves of Hungary, and it seemed clear that this was the centre of dispersion from which this culture had spread on the one hand into France, and on the other into Poland, where it underwent less change than in the West. A Magdalenian corresponding roughly to the Magdalenian III and IV of France was somewhat sparsely distributed in central Europe, and reached even into south-west Poland, while the final stages of the Palæolithic appeared to be represented both in Moravia and Poland by the industry of Font-Robert tradition which has since been named Swiderian, and which continues into the Mesolithic.

Of the Palæolithic of Russia very little was known, but that little suggested that it would prove to be of great importance. An industry of Upper Aurignacian type with objects in bone and ivory resembling those of Predmost had been found at Mezin in the Ukraine; at Kostenki, on the middle reaches of the Don, a similar station, further characterised by shouldered flint points identical with those of Willendorf and Predmost, had yielded a female statuette carved in mammoth ivory. Much farther to the east, in southern Siberia, G. von Merhart had excavated a number of stations on the upper reaches of the Yenisei, and had found a rather puzzling industry in which stone implements of both Mousterian and Aurignacian types were associated with objects of bone and ivory, such as points or awls with longitudinal grooves and a single specimen of a pierced *bâton* of reindeer antler. The fauna of these stations included rare specimens of mammoth and woolly rhinoceros, and Merhart considered that they should be placed at the end of the Pleistocene. Still farther east, at the Verscholensk Mountain near Irkutsk, B. E. Petri had excavated a site containing a stone industry with the same mixed characters as that of the Yenisei, associated with double-edged harpoons of reindeer antler, apparently rather of Azilian than of Magdalenian type. Mammoth and woolly rhinoceros were absent from the fauna, so this station was presumably later than those excavated by Merhart, and might even be of Mesolithic age. These Siberian industries, judging from the very inadequate accounts available, could not easily be fitted into the general framework of Eurasiatic prehistory, but they were generally referred to as an Oriental facies of the Magdalenian, with the implication that they were in some way related to the Magdalenian of the West.

To what extent has this general picture been modified by recent discoveries within and outside Europe? To begin with, it has become very much more complicated; in particular it is now recognised how large a number of diverse strains have hitherto been grouped together under the single heading Aurignacian. Furthermore, we have to revise



our views about the possible centre or centres of dispersion of the blade industries, and to envisage the possibility that they had already developed their main characteristics at a surprisingly early date.

I propose to consider one by one the regions which have yielded significant evidence in this matter, beginning with Europe. I cannot pretend to discuss every discovery of the last decade, but only to consider in a general way those which either throw fresh light on our problems, or introduce new and significant complications.

I begin with Perigord, a classic region for prehistoric studies, which might be supposed to have yielded long ago all the information which it had to give. Here we have to do, not with any new and startling discovery, but with patient and meticulous observations made during many years by Peyrony. The result of these is to emphasise the close relationship, already noted by Breuil and others, between the Lower and Upper stages of the Aurignacian, in contrast with the intrusive character of the Middle stage. Moreover Peyrony has found at Laugerie Haute an industry of blunted-back blades, underlying the true La Gravette level, which he compares with the industry of Bos del Ser in the Corrèze, excavated by Canon Bouyssonie, and with the upper Chatelperron level of La Ferrassie. This he considers to be the stage of transition between the Lower and Upper Aurignacian, and he suggests that at Laugerie Haute it represents an occupation of the shelter contemporary with the classic Middle Aurignacian of the neighbouring site of Gorge d'Enfer. He concludes that in the Chatelperron-Bos del Ser-La Gravette succession we are dealing with a culture totally different from the so-called Middle Aurignacian, and, in the Vézère basin at least, completely uninfluenced by it, and he proposes to group all those industries characterised by the blunted-back blade under the title of Perigordian, reserving the old name of Aurignacian for the industry of Gorge d'Enfer, Cromagnon, etc., which is marked by keeled scrapers, nose-scrapers, beaked burins, and by the split-base bone point, or *pointe d'Aurignac*.

This theory has been criticised by Breuil, who, while admitting the reality of the contrast between the Middle Aurignacian and the Chatelperron-Gravette levels (a contrast which he himself had already emphasised) considers Peyrony's view of the complete independence of the two traditions in the Vézère basin as too absolute, and points out that there is no stratigraphical proof of the contemporaneity of the Gorge d'Enfer and the Bos del Ser level of Laugerie Haute. He emphasises, however, that the notion of a double element in the Aurignacian must not be lost sight of, and we shall see later that discoveries in the Near East underline this view.

Quite recent work has thrown an unexpected light on the blade industries of the Iberian Peninsula. It has always been assumed that Spain was a purely Capsian province (with the exception, of course, of the Cantabric region, which showed the same succession as the French Pyrenees), but it is now clear that this view must be greatly modified. It had long been recognised that the wall paintings of the cave of La Pileta, in the province of Malaga, had close affinities with Franco-Cantabric art, but this isolated occurrence was regarded as a puzzling

anomaly. Quite recently, however, Señor Cabré has discovered remarkable parietal engravings in pure Aurignacian style in the caves of La Hoz and Las Casares, in the province of Guadalajara, not far from Madrid. Still more cogent proof that hunters from the north penetrated even into southern Spain is furnished by the excavations of Señor Pericot Garcia in the cave of Parpalló, in the province of Valencia. This site has yielded an apparently complete succession from Middle Solutrian to a Magdalenian corresponding more or less closely to the early Magdalenian of France. The Upper Solutrian, it is true, showed a great development of special forms, such as winged and tanged points, which seem to foreshadow the Neolithic—a peculiarity for which we were already prepared by discoveries in Catalonia—but the industries of the other levels conform to the classic Franco-Cantabrig types. Painted and engraved limestone plaques were abundant in the Upper Solutrian and Magdalenian layers, and Obermaier has pointed out that the style of these works has affinities with that of the East Spanish group of rock paintings.

Obermaier still regards the Franco-Cantabrig cultures as intrusive in the southern part of the Peninsula, and a re-examination of sites excavated by Siret in Almería and Murcia, and of other stations of this region, leads him to suggest there is a parallel development from a more or less typical early Aurignacian to a rather poorly characterised late industry for which he proposes the name epi-Aurignacian. He points out that it is only in the final stages of this development that Capsian influences appear, an observation which agrees with the late dating for the Capsian now proposed by Vaufrej. This theory of a local culture running side by side with the Solutrian and Magdalenian is still not very securely based, but it does appear that something of the kind is needed to account for the East Spanish rock paintings, which, in spite of affinities with the art of Parpalló, have many distinctive features which mark them off from the Franco-Cantabrig tradition.

In text-books written before 1928 references to the Palæolithic of Italy were very sketchy, and for the Upper Palæolithic it was usual to cite only the Grimaldi caves in the extreme north-west and the cave of Romanelli near Otranto. Vaufrej has now made a careful study of the subject, and has shown that the Italian blade industries present a single facies corresponding in time with the whole period of the Aurignacian, Solutrian and Magdalenian in France. This culture, which is characterised by shouldered points of flint and by a multitude of notched blades, is closely related to the Upper Aurignacian of the loess stations of Lower Austria, of which Willendorf is the type. Vaufrej proposes for it a separate name, Grimaldian, and this has now been generally adopted. The late and impoverished facies of this culture which is found in Sicily is not altogether unlike the Oranian or Iberomaurusian of North Africa, but Vaufrej rejects the idea of a direct connection between the two.

In Italy, then, as in Spain, we find in late Palæolithic times a close relation with the regions lying immediately to the north, with a tendency to local variations due to an isolated geographical position. The third great peninsula of the northern Mediterranean, Greece, has so far yielded



no Palæolithic remains of any kind, but it is difficult to believe that none exist. If and when they are found, they will almost certainly prove to be related to the cultures of Central and Eastern Europe.

If we now turn to the latter region, we find that in the last ten years nothing has been found to modify the general sequence already established for Upper Palæolithic times, though some supplementary evidence has been gained. In Moravia, Absolon's excavations at Vistonice have brought to light an astonishing collection of works of art associated with an Upper Aurignacian of the type of Willendorf, characterised by tanged and shouldered points and Gravette points. The excavator apparently considers this industry to be older than that of Predmost, but an unfortunate delay in the scientific publication of his results makes it very difficult for other workers to appreciate the evidence on which this conclusion is based. It would not appear, however, that the difference in time can be very great, since Predmost also yielded an industry of Willendorf type. The works of art from Vistonice include seven female statuettes and a number of animal figures modelled in a material which has been found on analysis to consist of bones ground to powder and baked or burnt, mixed with loess and worked into a plastic mass with water or fat—a new and rather surprising technique, unknown in any other age.

In Rumania Breuil had noted in 1925 the presence of a rough laurel-leaf tool of Hungarian type in a collection from the neighbourhood of Brasov, in Transylvania—an isolated find in a region which had otherwise yielded only an impoverished Middle Aurignacian. N. Morosan has now proved the existence, in stratified deposits in Moldavia and Bessarabia, of a Solutrean industry containing laurel-leaf tools of Hungarian type associated, as in western Europe, with Upper Aurignacian forms—a discovery which extends notably the area of distribution of the Solutrean.

The Swiderian of Poland is now established as of early Mesolithic date, and as forming one of a group of tanged-point cultures which spread across northern Europe from Belgium to the Ukraine at the beginning of the pre-boreal period. These cultures, however, undoubtedly have their origin in the Palæolithic, perhaps even in the final stage of the Aurignacian with its tanged and shouldered points. Schwantes and Rust have recently discovered near Hamburg an industry with tanged and shouldered points and reindeer antler harpoons which can be dated to the close of the Ice Age, and must therefore be in part contemporary with the final Magdalenian. In view of this discovery it is interesting to recall the reappearance of tanged and shouldered points in the Magdalenian VI of Perigord. The presence in Poland of a similar Palæolithic precursor for the Swiderian has not been definitely established, but it is considered possible that the three stations of Mielnik represent an early stage of this culture.

In Russia the last twelve years have been marked by discoveries of first-rate importance, associated with the names of Zamiatnin, Efimenko, Bontch-Osmolovski, Gerassimov and others. Up to the present, however, publication has admittedly not kept pace with discovery. The sites explored fall into four geographical groups; the open-air stations of the



South Russian plain, the caves of the Crimea, the caves of Transcaucasia, and the open-air stations of southern Siberia.

In the South Russian plain it has been possible to work out a probable succession of blade industries, though this is not yet confirmed at all points by stratigraphical evidence. The earliest group includes sites contained in loess or loess-like deposits lying either on the middle terraces of rivers, or on the slope of ravines, all of which date from a time before the laying down of the lower terrace deposits. Typologically these stations fall into two divisions, the first characterised by an industry of Willendorf type with shouldered points, and the second by a rather generalised Upper Aurignacian, with small blunted-back blades, round scrapers and angle-burins. The first division, which Russian workers consider the earlier of the two, includes such important stations as Kostenki I, Gagarino and Borshevo I, all on the upper reaches of the Don, and Berdysh in the Dnieper basin. We have already seen that a female statuette in mammoth ivory was found in this level at Kostenki I, and to this may now be added seven figurines of the same type from Gagarino, one of which bears a very close resemblance to the Venus of Willendorf. Associated with these were a number of points, needles and pendants in bone and ivory. The identity of this culture with that of Willendorf, Vistonice and Grimaldi is fully recognised by Zamiatnin, Efimenko and other Russian workers.

The second division includes Timonovka and Suponevo, on the Desna, and the well-known station of Mezin. Although the shouldered point is absent at this stage, the predominance of angle-burins and above all the geometric decorations on mammoth ivory of Mezin and Timonovka provide a link with Predmost, while the highly conventionalised objects from Mezin interpreted by Breuil as female statuettes represent the last stage of degeneration from the more naturalistic figures of Kostenki and Gagarino.

The next stage in the South Russian succession is represented by the stations of Kostenki II, III and IV, which have yielded a rather rough industry characterised by a very high proportion of polyhedral burins, associated with abundant remains of mammoth. I have not seen any drawings of this industry, but the description given by Efimenko suggests a possible analogy with the latest Aurignacian level in Palestine, to be described presently.

The final stage of the Upper Palæolithic sequence in South Russia is represented by the site of Borshevo II, which lies in the deposits of the lower terrace of the Don, and in part below the present level of the river. There are three culture layers, all of which contain an industry characterised by angle-burins, blunted-back blades and small round scrapers. The description and drawings given by Efimenko suggest that this has affinities with the level of Timonovka and Mezin, but the bone industry contains only simple points, awls and needles, without decoration. The lowest level of Borshevo II contained mammoth bones in abundance, but these became rarer in the middle stage and disappeared entirely in the most recent level, which Efimenko places at the beginning of the Mesolithic. The industry of this level, while remaining essentially

the same as that of the lower horizons, shows a certain evolution towards the type of the so-called Azilio-Tardenoisian stations of the South Russian plain. The final stage of the Upper Palæolithic represented in the lower level of Borshevo II is found also at Honcy on the Udai river, and in the upper level of the site discovered in 1897 in the Saint Cyril Street at Kieff.

It is noteworthy that no blade industry earlier than that of Kostenki I and Gagarino has yet been found in the South Russian plain, and that earlier Palæolithic stages are represented so far by a single Mousterian station on the Derkul river. Efimenko suggests that the swampy conditions which prevailed in this region in the Lower and Middle Pleistocene were unfavourable to human settlement. Certainly there is no geological evidence to suggest that the stations of the Gagarino group are not approximately contemporary with similar sites in central and western Europe.

In Southern Siberia, roughly two thousand miles to the east of the group of stations just described, Gerassimov has excavated a hut site at Malta, not far from Irkutsk. This contained a most remarkable series of objects in bone and ivory, including points, needles, rods and pendants, some of which are decorated with very small crescentic incisions giving the effect of punctuations. Twenty female statuettes carved in bone are more roughly made and, with few exceptions, less corpulent than those of Gagarino, but clearly belong to the same family. A group of curiously shaped objects supposed by the discoverer to represent birds are interpreted by Breuil as highly conventionalised human figures, but Gordon Childe insists that they are in fact birds. The lithic industry of Malta shows, in a lesser degree, the same mixture of Mousterian and Aurignacian forms as was found in the Yenisei stations and at the Vercholsensk Mountain. The fauna, however, includes mammoth, woolly rhinoceros, musk ox and glutton, so the site is clearly older than the Vercholsensk Mountain, and probably antedates the Yenisei stations also. The female statuettes form a link with the South Russian plain, but the bone objects as a whole have a very exotic look, and cannot at present be compared exactly with those from any other site. The mixture of Mousterian and Aurignacian forms in the stone industry is a feature which suggests possible connections with the Far East, since in 1924 Father Licent and Father Teilhard de Chardin found an industry of similar mixed character in the loess along the course of the Shuitungkou river in northern China. This culture Father Teilhard dates as Upper Palæolithic and himself compares it with the Yenisei finds.

The Crimea, although it lies so near to the South Russian plain, appears to belong to a different industrial province, and its caves were inhabited from the final Acheulian onwards. In the cave of Syuren I Bontch-Osmolovski has discovered a blade-industry sequence which appears to correspond rather closely with that of Palestine. It begins with an early form of Middle Aurignacian in which rough keeled scrapers are associated with small, delicately retouched blades. This is followed by a classic Middle Aurignacian, and the sequence closes with a not very typical Upper Aurignacian in which abundant polyhedric burins are associated



with microlithic blunted-back blades and rare Gravette points. Bontch-Osmolovski considers that this sequence represents the earlier stages which are absent in the South Russian plain, and places the stations of Gagarino type immediately after the Upper Aurignacian of Syuren I. Gordon Childe, however, suggests that this relative dating, based on typology, may be misleading, and I am inclined to agree, on the ground of the resemblance of the Crimean sequence with that of Palestine, which is known to cover the whole of the Upper Palæolithic.

Not much is known so far of the blade-culture sequence in Transcaucasia, but the description given by Zamiatnin of finds made up to the present suggests a general resemblance with the Crimea. This is what we should expect, since it is presumably by this route that the blade industries entered the peninsula.

The next link in the chain is found in the Middle East. In 1928 I was associated with a joint expedition of the American School of Prehistoric Research and the Sladen Memorial Fund to investigate the Palæolithic of Southern Kurdistan. In the caves of the Sulaimani district we found a highly developed Aurignacian of Willendorf type, with Gravette points, shouldered points, small notched blades, and microlithic lunates and triangles—the last named, however, being confined to the top of the layer. At the time of publication of these finds information from Russia was very scanty, and I mentioned the Austrian loess stations and the Grimaldi caves as the nearest comparable sites. I now realise that the Kurdistan industry, though possibly later in time, should be linked with that of Kostenki I and Gagarino, only 600 miles away to the north. At the same time, the microlithic forms and small round scrapers resemble those from the cave of Gvardzhilas Klde in Transcaucasia, a site which must also date from the very end of the Palæolithic.

The next region which has been investigated at all seriously is Palestine, where the excavations of the Institut de Paléontologie Humaine under Neuville and Stekelis, and the Joint Expedition of the American School of Prehistoric Research and the British School of Archeology in Jerusalem have established more or less clearly the sequence of blade cultures. These begin with a lower Aurignacian whose most characteristic implement is a triangular point with bulbar face flaking at the base, which occurs also sporadically in the Aterian of North Africa. Associated with this are blunted back blades, more or less of Chatelperron type, burins and end-scrapers. The industry as a whole, however, is more delicate and less primitive in appearance than that of the Chatelperron level in the West. It is followed by a Middle Aurignacian of primitive type with rough keeled scrapers and microlithic points, which appears to correspond with the earliest Upper Palæolithic stage of the Crimea. Next comes, as in the Crimea, a rich industry of classic Middle Aurignacian type, with keeled scrapers, nose-scrapers and beaked burins. The bulk of the Aurignacian of Palestine can be referred to this stage, and it is clear that it must cover the whole of the period which in the West is occupied by the Middle and Upper Aurignacian and the Solutrean. The industry of Antelias and the Nahr el-Kelb, near Beirut, described



by Zumoffen in the early years of the century, belong to this cycle, and Pittard has recently identified a similar facies in a rock shelter near Adi Yaman, in southern Anatolia. The closing stages of the Upper Palæolithic in Palestine are represented by an industry in which steep scrapers and polyhedric burins predominate, in association with occasional Chatelperron points. This does not correspond very closely with any other blade industry so far known, but descriptions given by Efimenko and Bontch-Osmolovski suggest, as I have already pointed out, a possible analogy with a late stage of the Upper Palæolithic in South Russia and with the final stage in the Crimea, though the Chatelperron point is apparently absent in those regions. Finally, it should be noted that, in contrast with the West, bone tools are excessively rare in the Aurignacian of Palestine, and so far no specimen of the split-base point has been found.

When we pass into Egypt we enter a world which was apparently cut off from the main line of development in Upper Palæolithic times, since blade industries proper are unknown before the appearance of the microlithic cultures which mark the close of the Pleistocene. Their place is taken by the Aterian, whose Upper Palæolithic dating has been demonstrated by G. Caton Thompson and E. W. Gardner in the Kharga Oasis, and by a peculiarly Egyptian culture, the Sabylian of Vignard, an industry of diminutive Levallois cores and small truncated flakes which at its first appearance has Levalloiso-Mousterian affinities, but eventually leads up to a form of Tardenoisian. For Vignard, indeed, the Sabylian is the parent of all the microlithic industries which surrounded and spread out from the Mediterranean basin in Mesolithic times, but this extreme view is not generally accepted, and most prehistorians would give greater weight than he does to regional differences in this stage.

I have said that until recently North Africa was regarded as the region from which successive Aurignacian invasions entered Europe. This part of the world still awaits systematic excavation, but Vaufrey's recent investigations have done much to discredit the old view, and it now seems more probable that in Little Africa the true blade cultures arrived late, their place in early Upper Palæolithic times being taken, as in Upper Egypt, by an industry in which Mousterian tradition was strong—the Aterian, in which triangular points and racloirs are associated with burins and end-scrapers and a peculiar, characteristic tanged point. The true blade industries fall into two groups, the Capsian proper, which is now perceived to be an inland culture, with its centre in the region of Gafsa, and the Oranian, or Iberomaurusian, which occupies the coast-line, its present identified limits being, roughly, Tunis on the east and Casablanca on the west.

Vaufrey has shown that the former division of the Capsian into a lower stage characterised by large angle-burins and curved points, and an upper stage in which microliths appear, is based on faulty methods of excavation. His own soundings in various sites have proved that microliths, and even micro-burins, occur already in the Lower Capsian, side by side with the larger tools. It therefore becomes impossible to correlate this stage with the Chatelperron level of Europe; it must fall

at the extreme end of the Upper Palæolithic, if not in the Mesolithic, and the Upper Capsian must, by definition, be later still. The only alternative to this view is to suppose that the microlithic facies appeared in Africa much earlier than in Europe—a theory for which at present there is no evidence.

The Oranian—I adopt the name suggested by Vaufrej, since it is now clear that the so-called Iberomaurusian does not occur in Spain—is a poor and monotonous industry. The bulk of its inventory consists of small blunted-back blades; end-scrapers and burins are very rare. The typical nucleus, made from a small pebble, resembles the Sabylian core, and, as in the Sabylian, miniature Levallois cores sometimes occur. In the Oranian sites excavated by Arambourg at Afalou-bou-Rhummel, in the department of Constantine, no micro-burins were found, but Vaufrej records that geometric microliths and micro-burins occurred in all the Oranian sites which he investigated, and he concludes that this industry is probably contemporary with the Upper Capsian. It is not excluded that some part of the Oranian may be rather older than Vaufrej thinks, but it seems probable that, like the Capsian, it belongs at most to a very late stage of the Upper Palæolithic.

Finally, a very interesting proof of connection between the Oranian and the Aterian was obtained at the open-air site of El Hank, near Casablanca. This was very carefully excavated by Lieutenant Brouaux, and the industry has been described by Vaufrej. El Hank contained two archaeological levels, of which the uppermost yielded a typical Oranian, and the lower an industry showing on the one hand definite Aterian affinities, in the presence of Mousterian points and tanged points, and on the other equally definite links with the Oranian, especially in its cores, which were identical with those of the upper level.

The rock paintings of North Africa Vaufrej now places in the Neolithic, since at all the sites which he examined the only implements to be found belonged to the Neolithic of Capsian tradition, and Obermaier, working on the basis of style and of the fauna represented, supports this view.

It is impossible in the time at my disposal to deal with the African continent as a whole; nor is the chronology of African prehistory sufficiently sure to make correlation with Eurasia anything but hazardous at present. On the whole I am inclined to agree with Vaufrej that Africa in Upper Palæolithic times was something of a backwater, and that more or less all over the continent industries of Mousterian type lingered on until and after the arrival of blade cultures in a relatively late stage of development. I would suggest that this is possibly the case even in Kenya, where Leakey has claimed a great antiquity for the Aurignacian. The only well-developed blade industry known at present (apart, of course, from admittedly late ones, such as the Elmenteitan) is the Upper Kenya Aurignacian, which is later than the second maximum of the Gamblian pluvial. By correlating Gamblian II with Würm II Leakey makes this stage contemporary with the Upper Aurignacian and Solutrian of western Europe, but in view of the fluid state of opinion in the matter of pluvials and glacials such a correlation can only be regarded as tentative. Vaufrej, and more recently S. A. Huzzayin,



suggest for Gamblian II a correlation with the final glacial stages (Bühl, etc.), and this agrees better with the typological evidence, since the Upper Kenya Aurignacian, with its microliths, micro-burins and pottery, has a definitely late appearance. Vaufreyc points out that, putting aside the pottery, it is in fact an almost typical Capsian. Such a dating would also rejuvenate the last phases of the Kenya Stillbay, since in Gamble's Cave a layer of this type was found between the Upper Kenya Aurignacian and the Elmenteitan. If we now turn backward in time we find that the Lower Kenya Aurignacian, which occupies the period from the beginning of Gamblian I to the second Gamblian maximum, is not at present known as a separate industry, but that crude backed blades do in fact occur side by side with Mousterian tools in deposits of Lower Gamblian age. Leakey makes out a good case for regarding these blades as belonging to a separate culture and not as part of the Mousterian, but he does not prove that this Aurignacian must necessarily be regarded as exceptionally early; it can equally well be argued that the Mousterian is a late survival. Here, again, the dating depends on the correlation of Gamblian I with Würm I, which has yet to be proved. I do not mean to suggest by this criticism that Leakey's correlations are necessarily incorrect, but simply that they are at present hypothetical, and give no solid ground for supposing that the Kenya Aurignacian is older than the Eurasiatic blade industries. On the other hand, the late survival, as in Little Africa and Egypt, of a culture of Mousterian tradition—in this case the Kenya Stillbay—is certain, even on Leakey's own dating.

We have now worked round to our starting-point, and it remains to see what general conclusions can be drawn from the material at our disposal. A point which stands out at once, and very clearly, is the diversity of the strains which have so far been grouped together under the name Aurignacian. As long as we were dealing only with Western Europe this did not matter very much, as everyone knew what was meant by the Lower, Middle and Upper Aurignacian, but when we come to regions in which the sequence is not the same, the use of these terms, with their chronological implications, is definitely misleading. Peyrony, as we have seen, proposes to retain the label Aurignacian for the culture so far known as Middle Aurignacian, and to group all the industries characterised by the blunted-back blade under the heading Perigordian. This undoubtedly corresponds with a first, very important distinction, which has been recognised for some time, but it does not go far enough. Perigordian, like the former Aurignacian, is made to cover too much. In spite of fundamental resemblances which certainly suggest relationship, it is doubtful if the passage from the Chatelperron to the Gravette level is the simple evolutionary process supposed by Peyrony. The blade cultures, after all, have an immensely wide distribution, and it is unlikely that the key to their development is to be found in southern France. If we take more distant regions into account it becomes clear that the French sequence is the result of successive immigrations, superimposed, perhaps, on a certain amount of local variation and development in place. Since, however, this sequence is so familiar, and has for so long been



accepted as a standard, I propose to make it my point of departure, and to examine its various stages in the light of the evidence now available, trying to trace each one back to its original centre. Afterwards it will be possible to shift our point of observation, and taking a wider view of the distribution map thus plotted, to see what general pattern emerges.

The first blade industry to reach Western Europe is that of the Chatelperron stage, Peyrony's Perigordian I, which is the former lower Aurignacian. The distinctive implement of this industry is, of course, the curved blunted-back blade, or Chatelperron point. The Chatelperron level—which, for convenience I shall provisionally call Chatelperronian—has not so far been found in Central and Eastern Europe, but a similar though not identical industry occurs at the base of the Upper Palæolithic sequence in Palestine. This, however, is less primitive in appearance than that of France, and seems already to be in process of evolution towards something resembling the La Gravette stage. We have seen that the Lower Capsian, which is characterised by curved points, was formerly regarded as the parent of the Chatelperron industry, but that Vaufreycy has demolished this theory by demonstrating that it is later in time. On the other hand, the Lower Kenya Aurignacian appears to be more or less of Chatelperron type, and may be in part contemporary with this stage in France. We thus have at the beginning of the Upper Palæolithic three areas which may in a wide sense be called Chatelperronian, two of which, Palestine and East Africa, may have been in touch with each other through Arabia and across the Bab-el-Mandeb, while the third remains apparently isolated. The problem of how the Chatelperronian entered Western Europe without leaving any traces on the way is one that awaits solution.

Although the Chatelperronian only appears as a distinct industry at the beginning of the Upper Palæolithic we can trace its essential features much farther back than this. The Levallois-Mousterian of Palestine, which covers a very long period, has yielded throughout a small proportion of well-made curved points, burins and end-scrapers and in the Tabun cave on Mount Carmel typical Chatelperron points, end-scrapers, and blades with abrupt retouch were relatively abundant all through a well-determined zone within the Final Acheulian. In Kenya also Leakey has found backed blades associated with the Upper Acheulian, and he suggests that the so-called Lower Aurignacian—the Chatelperronian—may have developed from the contact of the Acheulean and Levalloisian cultures, the makers of the Acheulian hand-axes borrowing from the Levalloisian the idea of making use of long narrow blades. This is not impossible, of course, but it should be noted that in the Upper Acheulian of Palestine, as in Western Europe, the flake industry which is actually associated with the hand-axes is in the Clactonian tradition, and the Chatelperronian tools look markedly out of place and intrusive, while in the Kharga Oasis, where a Levalloisian flake industry actually forms part of the late Acheulian, no Chatelperronian forms have been found. I should like to put forward the alternative suggestion that the Chatelperronian already had an independent existence at this time,

having developed in some centre still unknown, and that it is an intrusive element in the Acheulian. In trying to trace this centre, we must take into account the fact, which seems to me significant, that the two regions in which the presence of backed blades in the late Acheulian is clearly established are precisely those in which a distinct Chatelperronian industry appears at the beginning of the Upper Palæolithic. If—as I am inclined to do—we reject the theory that the Chatelperronian developed within the Acheulian, we cannot accept either Palestine or East Africa as its original home, but must place this somewhere within reach of both. An Asiatic centre seems inevitable, but it is impossible at present to be more precise. Investigation of that region which from the point of view of the pre-historian still justifies its name of the Empty Quarter should help to prove or disprove this theory, since it supposes that one line of migration passed through southern Arabia.

After the early stages of the Upper Palæolithic the Chatelperronian proper apparently ceases to exist. In Palestine, however, the Chatelperron point reappears unexpectedly in the final stage, which must be roughly contemporary with the Magdalenian, and it is present in the Lower Capsian at approximately the same moment. Now, Vaufreys's theory of the late arrival of the Capsian still leaves us in the dark as to its origin. In its general lines it is unlike either the Sabylian or the blade industries of Palestine. We have seen, however, that the Upper Kenya Aurignacian is a nearly typical Capsian, which seems to have developed in place from the so-called Lower Kenya Aurignacian. I would suggest that East Africa may possibly be the centre of origin of the Capsian, which would thus enter Little Africa already fully developed by way of the Sahara. The Capsian would thus derive many of its features direct from the Chatelperronian, though outside influences may also have played their part, especially in the development of the microlithic element. It is, for instance, unlikely that so specialised a type as the micro-burin should have developed independently in the Sabylian and the Capsian.

As for the peculiar industry which closes the Upper Palæolithic sequence in Palestine, it is quite definitely Aurignacian rather than Capsian, in spite of the presence of Chatelperron points, and it may conceivably be a local development, arising on the fringes of our hypothetical Chatelperronian centre and the Aurignacian province of the Near East.

Turning back to the Western European sequence we now reach the Aurignacian proper, the former Middle Aurignacian. Peyrony claims that this does not represent a real break in the sequence, but that the Perigordian continued to develop in certain sites side by side with the neighbouring Aurignacian. The stratigraphical evidence for this is, however, insufficient. Even if there is a certain overlap, as is probable, all the known facts are in favour of a general separation of the Chatelperron and La Gravette levels by the layers containing the Aurignacian.

This industry can be traced right across Europe, through Lower Austria, Hungary, Rumania, the Crimea, Transcaucasia and Anatolia into Palestine, where it is very abundant and covers a much longer period than in the West. This suggests that the East Mediterranean coast is not very far



from the Aurignacian centre of dispersion, and I would suggest tentatively that this should be sought somewhere in the Iranian plateau.

It has not been possible to distinguish in Palestine the various subdivisions of the Aurignacian which have been worked out for France, and which to some extent must represent local developments. It should be noted, however, that the French divisions are based in part on the bone tools found at different levels, and in Palestine, although animal bones are usually abundant, bone tools are excessively rare. A possible explanation of this may be that the bone tools of the West had wooden prototypes in the Near East. The large amount of charcoal found in Aurignacian layers in Palestine shows that wood was still readily obtainable, though the fauna points to gradually increasing desiccation.

It is an open question and a very difficult one, how far the Aurignacian and Chatelperronian have ultimately a common origin. Certain forms, such as the burin and end-scraper, are found in practically all blade industries, but the Aurignacian, with its use of types derived from cores and consequent development of a fluting technique, has distinctive features which point at least to independent evolution from an early date.

The next stages in the French sequence are those of La Gravette and Font-Robert, formerly grouped together as Upper Aurignacian, which Peyrony has labelled Perigordian IV and V. This industry has clear affinities with the Capsian, and in view of the possibility that the Lower Capsian may be roughly contemporary with it, the question of African influence must be re-examined at this point. For various reasons, however, I think it must be ruled out. Already in the Lower Capsian two very distinctive forms, the micro-burin and the microlithic lunate, are present, and if this industry were the parent of the Gravette-Font-Robert stage of Europe it would seem inevitable that these should occur there also. In fact, however, they enter Western Europe only with the Tardenoisian culture at a much later date. Again, if the Lower Capsian passed into France it must have been through the Iberian Peninsula, and we have seen that in that region Capsian influences appear only at the close of the Upper Palæolithic sequence. Finally, the Gravette-Font-Robert industry has a very wide distribution in central and eastern Europe, and its remarkable development in this region points rather to a Eurasiatic origin. If further evidence were needed, one could cite the complete absence in Little Africa of the very distinctive female statuettes which are constantly associated with this culture in Europe. It does not follow that there is no link between the Capsian and the Gravette-Font-Robert industry; I would suggest that both are derived from the Chatelperronian, but that their common features are due in part to convergent development, certain forms, such as the Gravette point, being evolved almost necessarily from their Chatelperronian prototypes.

I have suggested that an Eastern origin is indicated for the Gravette-Font-Robert industry, and we must now examine this rather more closely. In France the distinction between the Gravette level with its typical blunted-back blades, and the overlying Font-Robert level with tanged and shouldered points is quite clear, but the two are nevertheless



very closely related. In Central and Eastern Europe the shouldered point stage predominates and is associated with a distinctive decorative art and apparently a great development of the cult of which female statuettes are the expression. I would suggest for these two very closely related levels the names of Lower Gravettian and Upper Gravettian respectively, the label Grimaldian being reserved for the special development and prolongation of the Upper Gravettian in the Italian Peninsula.

The theory of an eastern centre of dispersion for the Gravettian is based, of course, on this exceptional development in Central and Eastern Europe. I am influenced also by the fact that the female statuettes, whose close connection with the Upper Gravettian is incontestable,<sup>1</sup> are very abundant in Russia, but occur only sporadically in Western Europe, where they have an unmistakably alien appearance in comparison with the indigenous naturalistic animal art which had already begun to develop in the Aurignacian.

Assuming an Eastern origin, we cannot regard Central Europe as the centre of dispersion, because we have clear evidence that the Gravettian is there preceded by the Aurignacian proper. In South Russia it is indeed the oldest blade industry so far found, but the geological evidence does not suggest that it is necessarily very early, though it may quite well be contemporary with the Aurignacian of the West. I do not think, however, that the centre of dispersion can lie very much farther to the East, because the lithic industry of Malta, which must be approximately contemporary, is not Gravettian at all, though the presence of statuettes and certain decorative motifs suggests either that Siberia was reached by influences from South Russia or that the particular cult of which female statuettes were the expression came to the Gravettian from the Far East.

We must now consider by what route an industry ancestral to the Gravettian could have passed into North-east Europe from our hypothetical Chatelperronian centre. We have seen that in Palestine the true Gravettian is absent, and that in southern Kurdistan it probably represents a relatively late migration from Russia. In Palestine, however, the Chatelperronian level which lies at the base of the Upper Palæolithic sequence already shows signs of evolution towards the Gravettian type, and it is possible that an industry of this character had already penetrated into the neighbourhood of the South Russian plain before the westward moving Aurignacian invasion had reached the Mediterranean coast.

I need not dwell on the Solutrian episode, which forms the next stage in the French sequence, as this is already well known and understood. The only addition to our knowledge in recent years has been the demonstration that the Solutrian penetrated farther to the east than was originally supposed from its Hungarian centre.

With the Magdalenian we reach a stage when migration on a wide scale gives way to local variations of the cultures already in possession.

<sup>1</sup> At Sireuil and Brassempouy female statuettes were apparently associated with the Aurignacian proper, but in neither case is the evidence absolutely conclusive. Should the association be proved, however, these two isolated instances might suggest an early intrusion from an already established Upper Gravettian province in the East.

Apart from the Magdalenian itself, which is undoubtedly the most interesting and the most vital of these variations, we have the Grimaldian in Italy, in South Russia a degenerate industry of Gravettian tradition, in Palestine a kind of hybrid Aurignacian which may extend into the Crimea, in Egypt the Sabylian, in England the Creswellian, while the retreat of the ice sheet in northern Europe made way for the Hamburg culture which is apparently derived from the Upper Gravettian. To round off completely the story of the Palæolithic blade cultures it would be necessary to pursue a number of these branches into the Mesolithic, but the time at my disposal makes this impossible. In any case the close of the Pleistocene, for general purposes, marks the end of an epoch in human history, and although no catastrophic change is visible, with the dawn of the Mesolithic a new order is already on its way.

If we now take a last general view of this theoretical picture, we see the Chatelperronian, the earliest identifiable phylum of the blade cultures, already emerging in Lower Palæolithic times, in some as yet unidentified Asiatic centre. Ultimately it sends out two branches, one into East Africa, to give rise to the Capsian, the other into North-east Europe, to develop into the Gravettian. Meanwhile another stock, the Aurignacian, pushes westward, and separates these two great provinces. From the Aurignacian and Gravettian centres migrations pour into Central and Eastern Europe along the southern edge of the ice-sheet, and cultures which in their homelands tend to remain distinct and exclusive succeed and influence each other, until at the extreme limit of their journey we get the characteristic French sequence, which for so long was used as a standard for the rest of the world. Meanwhile along the fringes of the original provinces interpenetration necessarily takes place, and we find the Upper Gravettian filtering along the valleys of the Zagros Arc into southern Kurdistan, while the Aurignacian penetrates northward into the Crimea. Finally, at the close of the Pleistocene, migration on a large scale comes to an end, and numerous local variations spring up all over the Palæolithic world.

Outside all this, meanwhile, lies the still mysterious Far Eastern province, with its mixed flake and blade culture. In its early stages this may conceivably have played a part in the evolution of the Aurignacian proper, and in this connection it is perhaps significant that Gordon Childe reports the presence of a split-base bone point at Malta.

The picture which I have outlined is admittedly largely speculative, and the most that I hope for this address is that it will ultimately stimulate discussion and disagreement. I am prepared to be accused of domination by a *mirage orientale*, but to that I would reply that some of my colleagues seem to me at the moment to be unduly influenced by a *mirage africain*. Only further discovery will make it possible to decide between us.

## SECTION I.—PHYSIOLOGY.

# THE CONTROL OF THE CIRCULATION OF THE BLOOD

ADDRESS BY

PROF. R. J. S. McDOWALL, M.D., D.Sc., F.R.C.P. (EDIN.),  
PRESIDENT OF THE SECTION.

It is now more than 300 years since William Harvey discovered the circulation of the blood, but we are yet far from understanding its control—a fact which is brought home to us when we realise that each year thousands of people die from failure of the circulation other than heart disease. Indeed it can fairly be said that certain diseases of the circulation are definitely diseases of civilisation and are on the increase.

The purpose of the blood circulation is to supply the tissues with nourishment and particularly with oxygen, and since the different parts of the body vary enormously in their activity from time to time, their needs vary also.

In this address I shall endeavour to indicate the various kinds of mechanisms which work together in order to provide adequate blood supply to any part of the body, whatever its activity or whatever the posture of the body.

For the sake of simplicity I shall confine myself to the effects of physical exercise, since most of the mechanisms which I shall describe are brought into operation thereby, although they are also used for other purposes.

When a tissue, say a muscle, increases its activity, it needs more oxygen and fuel and therefore more blood supplied to it per minute, and this increase is brought about in two ways: (1) by the same blood being pumped round the body more rapidly—that is, by increased activity of the heart, or pump; and (2) by utilising blood which previously went to other less active and for the moment less important parts of the body—that is, by re-distributing the blood. This is accomplished by varying the calibre of the blood vessels and has two effects. It alters the resistance to the blood flow to any particular region, and it alters the capacity of any organ or part of the body, but since there is only a limited amount of blood in the body, it is evident that, if the circulation is to be maintained, vessels opened up must not exceed the capacity of those closed down.

### VARIATIONS IN THE ACTIVITY OF THE HEART.

This I shall summarise rapidly, as much of it is sufficiently old to be in most of the text-books, and perhaps I should say that throughout I shall



dwell particularly on those parts of the subject which are as yet less generally known.

The heart is not like an ordinary pump which sucks fluid from one tube and pushes it into another. The veins are so thin that any degree of suction would cause them to close. The heart is filled by the pressure of the blood which reaches it during the time it is relaxed, and adjusts the force of its stroke to the amount of blood in it at the beginning of contraction. The more blood reaching it, the more it pumps out, within limits. This is made possible by the fact that the force with which the heart contracts is increased if the heart muscle is stretched.

The heart can also change its rate. In the past it has been usual to describe the heart as being under two sets of controlling nerves, one the sympathetic, which when stimulated makes the heart go fast, and the other the vagus, which makes the heart go slower. Now we know that this is only part of the story. The evidence is almost complete that the heart is really under the control of two sets of reflexes which have this function. The difference between these statements is that the second involves an afferent pathway to the central nervous system, for the sympathetic and the vagus are constantly carrying down impulses to the heart, and if they are cut off the heart goes slow or fast as the case may be. In the case of the sympathetic we do not know accurately as yet the exact source of the afferent impulses, but the fact that stimulation of any sensory nerves causes cardiac acceleration suggests that the source is stimulation from the outside world. This is not necessarily conscious, for it has been shown that a sound may accelerate the heart of a person who is asleep but during waking hours the higher centres undoubtedly play a part in the acceleration. I shall refer to this further in relation to the vaso-motor centre. In the case of the inhibitory impulses which slow the heart the source of the afferent impulses is known. These arise from certain sensitive regions within the circulation itself. These are situated in the left side of the heart, the arch of the aorta and the carotid sinuses, which are small dilatations at the bifurcation of the common carotid artery in the neck. We know these facts because section or anæsthesia of these nerves has the same effect as section of the vagus side of the reflex arc, and it can be demonstrated that nerve impulses which can be recorded electrically are constantly passing up the nerves from these regions. The normal method of stimulation has been shown to be the change of blood pressure in these parts of the circulation at each beat of the heart.

When exercise is taken, two changes occur: the sympathetic accelerator impulses increase and in particular the vagus impulses are reduced. The evidence for this rests on the effect of exercise and other procedures on the heart rate before and after section of the vagi and with and without the sympathetic. It has been shown, for example, that if the vagus nerves have been cut the increase of the heart rate is, during the exercise, not nearly so great as it was before they were cut. It is not possible for me to discuss here how the change is brought about, except to say that it is in part due to the action of the higher centres and to a rise of venous pressure. The increased temperature of the blood and adrenaline liberated by the suprarenal gland enhance the effect of the nervous changes; but there is not time to go into this in detail.

What I do want to emphasise is that the range of acceleration is deter-

mined by the degree of activity of the cardio-inhibitory reflexes: indeed, it has been recently shown in Belgium that the capability of dogs to withstand sustained activity is apparently enhanced by removal of the sympathetic. The extent to which the animals have then to rely on the reduction of vagus activity is thereby increased. This of course does not mean that the maximum effort for short periods is increased. To show this it is necessary to time the running of the animal over short distances. It has been shown that in athletes during mild exercise the cardiac output is increased with a trivial increase in cardiac rate—that is, the increase is chiefly produced by an increased output per beat. I shall, however, return to this point. Meantime I should like to leave you with the question: The heart increases its output; where does it get its blood?

Experimentally it can be demonstrated that the vagus restraint of the heart is extremely variable—not only in different animals, but in the same animal under different conditions, as may be seen if we block the vagi. For example, if we give an animal nitrogen to breathe, the normal vagus restraint can be shown to have disappeared. Or we can increase the restraint by previous sensory stimulation. This last experiment is of special interest, as it may give a clue as to how the normal vagus restraint is built up. We know that animals and human beings which take large amounts of exercise have slow hearts. How exactly this slow heart is produced is not yet clear. All we can say at the moment is that certain procedures such as sensory stimulation or asphyxia increase the heart rate, partly by reducing vagus activity, but that subsequently this reduction is followed by an increase in the activity of the vagus. I would indeed be glad if anyone could make any suggestions on this point.

#### VARIATIONS IN THE CALIBRE OF THE BLOOD VESSELS.

As I have said, it may be taken as a general principle that in physical exercise the blood is distributed to the active tissues at the expense of the less active tissues. This local dilatation of vessels, combined with a rise in the general blood pressure which is the result of increased cardiac output and constriction of vessels in less active tissues, results in an enormous increase in blood flow through the active muscles. This increase has been measured for the vessels of the lower lip of the horse, and may be demonstrated in an anæsthetised animal. The dilatation is brought about by chemical and nervous means, and on this point an enormous amount of work has been carried out in recent years.

*The cause of the chemical dilatation* has been a matter of considerable debate. It has been demonstrated that blood issuing from tetanised limbs has a vasodilator action. There are first to be considered the products of carbohydrate metabolism—carbon dioxide and lactic acid. Each of these has been observed to cause vasodilatation if applied in suitable concentrations to capillaries under the microscope. I emphasise the concentration because larger concentrations have the opposite effect. It may be demonstrated also that, if the vessels of the hind limb of a chloralosed animal are perfused with the nerves intact and carbon dioxide is administered, the perfused vessels constrict because of the action of the carbon dioxide on the vasomotor centre, but the blood-pressure does not neces-



sarily rise, presumably because there has been a compensatory dilatation of vessels in the rest of the animal. A number of workers, especially Fleisch, have demonstrated that vessels are sensitive to most minute changes of hydrogen-ion concentration, even that which is produced by the addition of the normal amount of carbon dioxide to the blood, and personally I think that normally this is the most important factor concerned.

There is, however, evidence that certain substances of protein origin may be involved. Of these the most important is histamine. It has recently been shown by Anrep that the vasodilator substance which is liberated into the venous blood gives all the known biological reactions for histamine, and it is possible to demonstrate that extensive tetanisation of muscles may produce a state which is a very similar one to histamine shock. There is at the same time a constriction of pulmonary vessels such as is produced by histamine. This liberation of histamine—if it be histamine—is of interest, as biochemists have reported that, compared with other tissues, muscles contain relatively little histamine. It is, however, somewhat doubtful if we are justified in considering that what happens during a severe artificial tetanus necessarily occurs in normal exercise.

It has been suggested also that other substances of protein origin, such as adenylic acid, may be concerned. Whatever the agent it seems likely that some metabolic products are responsible, if not for the dilatation during exercise, certainly for the continued dilatation which continues after the exercise.

*The nervous dilatation* is, judging from the work of Cannon and his associates, probably sympathetic. Here we see a dual function of the sympathetic, for its constrictor action is much better known. It has been known for some time that the sympathetic contained vasodilator fibres. Indeed, Dastre, a successor of Claude Bernard, states that, had Bernard chanced to use a dog instead of a rabbit for his classical experiments on the sympathetic, he would have been more impressed with its vasodilator than with its now much better known vasoconstrictor action. In order to show the vasodilator fibres in the sympathetic, it is necessary to paralyse first the vasoconstrictor fibres with ergotoxine (Dale), or to use slow rates of stimulation. In this connection it may be remarked that this slow rate of stimulation may be an imitation of what normally occurs, since presumably ordinary muscle contraction may give rise to similar stimuli. It is interesting to note that the dilator action is easily shown in the dog, but it has not been possible to show it in the cat; but the exact significance of the point is unknown.

Once the exercise has begun it seems likely that local vasodilator reflexes, similar to Lovén reflexes, are set up by afferent impulses arising within the muscles themselves, possibly as a result of the mechanical and chemical changes which take place. The evidence is somewhat scanty, but it is impossible to ignore any longer the possibility of the existence of a nutrition reflex as suggested by Hess and supported more recently by Fleisch. By this is meant the fact that oxygen lack in a part sets up afferent impulses which result in reflex dilatation.

*Capacity effects.*—Now it has been shown by Krogh that when a muscle is active an enormous number of hitherto closed capillaries open up. The best evidence of this is probably his well-known Indian ink experiment.



This opening up of vessels previously closed necessitates the provision of blood, and as there is only a limited amount of blood in the body, it must be provided from other regions, otherwise the blood pressure would fall and the circulation through the tissues be reduced.

It is probable that practically all parts of the body, except possibly the voluntary muscles, the heart muscle and the brain, provide the blood necessary for the active muscles. It has been shown that any exercise, actual or even contemplated, causes vasoconstriction. Constriction of the spleen and of the intestine in animals has been observed. This was the subject of a presidential address to this Section by Barcroft some years ago. In man it has been shown that the vessels of the skin constrict under any emotional stress or even anticipated activity. This, indeed, was one of the first facts discovered by Mosso with his plethysmograph.

In regard to the sympathetic constriction of the vessels, we are in the same difficulty as we were in relation to the sympathetic acceleration of the heart. We do not know how the actual nerve impulses which originate the constriction arise. For convenience we say that they begin in the higher centres of the brain. It is, however, probably preferable, it seems to me, to consider that it is a sensory stimulation from the outside world, which is the point in time which determines the psychical reaction which results in motor movement. Certainly we know that stimulation of a sensory nerve causes generalised vasoconstriction and commonly a rise of blood pressure, and that similar changes but of lesser degree may be recorded in a sleeping man.

It has been usual to ascribe the shutting down of the blood vessels solely to sympathetic activity, just as it was usual to ascribe cardiac acceleration solely to such action. In the case of the heart we have clear evidence that the reduction of the vagus restraint is just as important by increasing the range of cardiac activity and creating a cardiac reserve. It has now become evident that there probably exists an exactly parallel mechanism which increases the range of vascular activity and similarly enhances the reserve.

#### THE MAINTENANCE OF THE VASCULAR RESERVE.

Just as we have the restraint of the heart by the vagus, which determines the range of cardiac acceleration, so we have in relation to the blood vessels a set of reflexes which determines the magnitude of the vasoconstriction of the blood vessels. That is, they maintain the vessels of the body generally in an actively dilated state. The afferent impulses which are concerned in these reflexes have an exactly similar origin to those responsible for the vagus restraint of the heart. They arise from the cardio-aortic region and the carotid sinuses, and pass up the medulla by the aortic and carotid depressor nerves. The evidence for this statement is essentially that if the afferent impulses from these regions are cut off, there results a constriction of practically all the blood vessels in the body. It may be remembered that for many years the existence of such tonic dilator control of the vessels was denied, but the experiments on the carotid sinus by Hering, Heymans and their co-workers have placed it beyond doubt. Like the cardio-depressor reflexes the vascular-depressor reflexes are operated by the intravascular pressure in these regions.

It has been generally assumed that the primary function of this control of the vessels is to maintain the arterial pressure at a constant level, and this is quite reasonable, for a constant mean pressure is desirable to maintain a steady flow of fluid at rest from the capillaries to the tissues. It can be shown that if these reflexes are put temporarily out of action, considerable variation in pressure is liable to occur because of the spontaneous contraction of certain vascular regions such as the spleen.

More recently it has become evident that these reflexes may have another and possibly more important function. Several facts led to this suggestion: (1) that in physical exercise or mental stress, the blood pressure, like the heart rate, does rise in spite of the reflexes; (2) that the response of blood pressure to posture may be normal if the reflexes are destroyed—a fact which shows that the maintenance of mean pressure is not wholly dependent on the reflexes; (3) that as in the case of the vagus, different animals, or even the same animals in slightly different circumstances, show great variability in the activity of the reflexes—often it is possible to throw the reflexes out of action without affecting the blood pressure materially; and (4) as might almost be anticipated, the conditions which reduce the activity of the vagus also reduce the activity of the depressor reflexes. Two procedures which produce most striking results are the raising of venous pressure by the rapid injection of fluid and the injection of adrenaline. It may be remembered that Bainbridge showed that the rapid injection of fluid into the veins causes reflex cardiac acceleration, partly by reducing the action of the vagus. This was the experiment which led to the discovery of the right auricular reflex usually associated with his name.

Now since in exercise the venous pressure is increased and, if the stress of the occasion is sufficient, adrenaline is secreted, we may consider what happens to the circulation when the vasodepressor reflexes are thrown out of action. As I have said, there is a rise of arterial pressure and a generalised constriction of the vessels. It has become usual to consider that this rise of arterial pressure is the result of an increased peripheral resistance to the flow of blood from the arteries. Were this wholly true we should expect to find that there is a reduced flow of blood to the veins. If the animal, however, is in good condition, the reverse is the case: there is an increased flow to the veins. It is as if there were at the periphery a sponge-like reservoir which, when it is contracted, drives its store of blood into the veins. In this connection it is interesting to remark that Bayliss when investigating the aortic depressor nerve found that stimulation caused not only a fall of arterial pressure, but a fall also of the venous pressure—that is, an increased capacity of the circulation. He did not consider the reverse possibility, since the then unknown function of the carotid sinus prevented his discovery of tonic dilator impulses.

When the depressor reflexes are cut off, the reverse, however, does not necessarily occur experimentally. An increased flow into the veins does not necessarily result in a rise of venous pressure, because at the same time the heart is stimulated and the increased pressure is rapidly dealt with. It can, as might be expected, be shown at the same time that there is an increased output of the heart. It is not possible to measure the output of the heart by the cardiometer method without there being some



degree of shock or permanent increased capacity of the circulation from the absorption of toxic products. As a result, the increased cardiac activity more than balances any increased flow in the veins, and the venous pressure may actually fall. Commonly it remains unchanged in such experiments. However, if the animal is not subjected to any severe operative procedure, a small rise of venous pressure is the rule. Perhaps I should say that several workers using the Fick method have shown an enormously increased output of the heart when the impulses from the carotid sinus are cut off.

In doing such experiments we must attempt to imitate physiological possibilities. If, for example, we cut off all the depressor reflexes completely and suddenly, there is such an enormous rise of venous pressure and arterial pressure that the heart may fail and the cardiac output be reduced.

What we can imagine happens in exercise or emotion is, then, that just as the vagus restraint of the heart becomes reduced, so also the depressor restraint of the vessels becomes reduced, more blood is thrown into the circulation and is dealt with by the heart, which at the same time increases both its rate and its output per beat. It is to be anticipated that we shall eventually get evidence that the extent of the activity of the vasodilator reflexes varies in different animals just as the activity of the vagus varies.

*The sympathetic and adrenaline.*—All the mechanisms which I have described are probably still further enhanced by the vasoconstrictor action of the sympathetic and the action of adrenaline, which is apparently secreted whenever the emotional stress of the occasion is sufficient. Adrenaline in physiological amounts constricts the vessels of the skin and splanchnic region and dilates the vessels of the muscles. Here I should like to emphasise that probably the physiological dose of adrenaline is minute, and may even be insufficient to raise the blood pressure. Certainly the dilatation of muscle vessels is not a result of the rise of blood pressure which may occur, for it can be shown that the dilatation occurs with doses which do not raise the arterial blood pressure. An increased blood flow through the limbs can also be shown to be brought about by doses which do not raise the blood pressure. In such circumstances the constriction just counterbalances the dilatation. Why adrenaline should constrict some blood vessels and dilate others is a major problem in the study of the circulation. Since so far as we know the vessels themselves have the same structure in different parts of the body, we must assume that the difference is due to the different environment. I had hoped by this time to have obtained some definite evidence on this point, but so far the experiments have not been completely successful.

It is interesting to observe the effect of adrenaline on the depressor reflexes. If the hormone is injected it is found that some minutes afterwards, even after the usual rise of blood pressure has passed off, it is not possible to affect the heart by a degree of stimulation of the vagus which was previously effective, and at the same time the effects of cutting off the impulses from the carotid sinus are markedly reduced or completely abolished. This, of course, is exactly what would be expected if adrenaline were secreted in the same circumstances in which the action of the depressor reflexes and the vagus are reduced, as in exercise.



A further corroboration of this somewhat new view of the function of the vasodilator reflexes comes from a study of the effect of exercise and of emotion on man. It is well known that when a man takes exercise on a stationary bicycle his systolic blood pressure goes up, but falls even below normal the moment the exercise stops. This fall has been explained by Cotton, Slade and Lewis as due to the accumulation of blood in the vessels of the dilated muscles, but from what I have said in relation to the diminution of the peripheral resistance in muscle, it is evident that the fall is in part due to a diminution of this resistance. Now if a careful comparison be made of the psychical effect of intended exercise and that of exercise, it has been found by Gillespie that there is no difference. In other words, the rise of arterial pressure in exercise is the result of psychical changes. If exercise could be taken without psychical zest being involved, we might expect the blood pressure to fall. This, indeed, has been found to occur in the horse. In man, too, it has been found that if the exercise is slight, although the systolic arterial pressure rises, the diastolic pressure falls. This means that more blood is being pumped out of the heart per beat, but that blood escapes from the arteries more rapidly than normally before the next systole. In other words, from psychical causes alone there is a rise of arterial pressure from an increased cardiac output per beat, which can only be the result of more blood reaching the heart. In emotion too it is known that the systolic pressure rather than the diastolic rises. Since we have seen from the experiments of Mosso with the plethysmograph, of Barcroft on the exteriorised spleen and of Florey and Florey on the exteriorised colon, that generalised vasoconstriction is an accompaniment of psychical effort, we must assume that the increased output of the heart is in part, if not wholly, the result of the vasoconstriction which calls into use the reserves of blood and thus the circulation is maintained in spite of the greatly increased capacity of the active muscles.

I am afraid that as I have gone along you have gradually become aware of the complexity and difficulty of the problem. The difficulty is enhanced by the fact that in the circulation we have so many variables, and, the moment we attempt to isolate one, we are at once liable to introduce abnormal conditions.

In discussing changes which may occur in exercise, I have tried to give you an idea of the circulation as a working whole. For a physiologist the investigation of such questions is something interesting to do, but we must remember it is these same mechanisms which the body uses and develops for physical exercise which the body uses to defend itself against disease and injury. It is well that we should remember the words of the late A. D. Waller to this Section some years ago:

'Physiology must be studied for its own sake, but the physiologist whose immediate motive is the *want to know* may not deny his debt of service to the community of which he forms a part and whose services he enjoys. And the channel through which he can repay some part of that debt lies first of all in the service he may be able to render to the practice of medicine—to the knowledge and power of the physician whose immediate motive is the *want to help*.'

## SECTION J.—PSYCHOLOGY.

# THE PATTERNS OF EXPERIENCE

ADDRESS BY

A. W. WOLTERS,

PRESIDENT OF THE SECTION.

ONLY two years ago our lamented Past-President, Dr. Shepherd Dawson, gave an admirable summary of the contributions which psychology is making to the life of the modern world. As I considered the choice of a subject for this address I concluded that it was too early to cover that ground again, and I decided that it was consistent with the duties of a President of Section J to put forward certain of his own reflections, which are related to and, indeed, largely stimulated by contributions to the sectional programme of the previous year. While thinking over the Aberdeen address it occurred to me that any comprehensive review of psychological progress is bound to skim rather lightly over many matters which are highly controversial. These controversies, and the conflict of authorities, provide a ready weapon for the critics of psychology, of whom there are still too many who base their objections upon ignorance and prejudice. May I spend a moment of my time in a short, active defence of my colleagues?

Every natural science has as many vigorous controversies as psychology. The only difference is that since our science has so far had neither the time nor the number of workers to acquire so great a content of established fact as the other disciplines, the student finds himself facing controversies at a very early stage. But controversy is the breath of life to science. Is it not the case that every scholar loses interest in a topic as soon as it is settled? They who value knowledge so highly, value still more highly the process of coming to know. Appearing in public as the high priests of knowledge, they worship privately at the shrine of the unknown. Behind my metaphor lies the distinction between science and the scientific text-book. Science grows by discussions, which the outside world calls disputes. So let us not be ashamed of our civil wars, though the smoke of battle may hide from the general public the solid progress which is being made. Now, it is a fair deduction from this, I think, that those who surrender themselves too completely to a 'school' are wilfully fettering their minds. It is impertinence to suggest that the distinguished workers along any one line can be entirely wrong, and it is obvious that they cannot all be right. So a judicious and critical selection from opposing theories is a reasonable attitude. No doubt, however, members of each and every school of thought will find stinging retorts to this eclectic speaker. I freely grant that eclecticism can be carried too far, and that its results are of little worth unless pulled together by a personal point of view. I propose, then, to put my own point of view again, and to take as my texts two papers read before the Section last year at Norwich. My regard



for them is certainly not diminished by the fact that the views they express closely resemble my own. But, fortunately, even if there are prejudices observable in this paper they will but be additional illustrations of the opinions expressed therein. Psychology should begin at home.

The first of these papers is the impressive address by Prof. Rubin, devoted to the 'ways of seeing.' Summing up his important contributions to the psychology of perception, he demonstrated to us that perceptual cognition is shot through with suggestions of movement and direction which are not reducible to the geometry of the object. The mind contributes structural principles to its own experience. Like many scientific theories this was not new. Many besides Rubin, and many earlier than he, have suggested that the mind, at least in part, makes its own experience. The value of his contribution lies in the beauty of his experimental development of the theme, and in the detailed application of it. But at least one of his demonstrations at Norwich was so new to most of us as to be thrilling. Those of you who were present will remember vividly how we were brought to recognise that pictures in European art have a definite left-to-right character, upon which their meaning and æsthetic appeal largely depend. I reported this to Mr. Betts, the head of the School of Art in my university. We went through his stock of lantern slides, and found that in nearly every case Rubin was clearly right. But our most exciting moment was that in which we discovered a drawing in which Rembrandt had gone astray. My colleague suggests that Rembrandt made his sketch from a mirror, a quite usual method, so that having posed his model correctly—that is, as Rubin would have had him do—and being absorbed by the technical problems of his sketch, he overlooked the extraordinary and unpredictable effect of the lateral inversion.

It seems clear that there are pre-established manners of seeing, and we must expect the same to hold in the other modalities of sense. This implies that the patterns of our perceptual experience are dependent upon the mind, in some cases, perhaps, upon its original endowment, in others upon acquired factors. Thus Rubin suggested that the left-to-right direction of European pictures was derived from reading left-to-right script. Mentioning this to one well known in another section of the British Association, Mr. Peake, I was advised to try out the theory on cave drawings. I have not had the leisure to do so extensively, but in some at least there appears to be the same suggestion, and I have not yet observed the contrary direction in any case. So far as this evidence goes, it tends to confirm my suspicion that right-handedness is among the determinants of perceptual direction. But whether we accept Rubin's view as sufficient, or add my own suggestion to it, it appears that perception can be shaped by factors extrinsic to the material experienced. Under their influence the mind is creating, is actively patterning its experience, so that in some sense and to some degree (the limits being determinable by experiment) the mind makes the world it knows.

If controversy be good for science, we have reached a fruitful spot. The objections raised by some philosophers that on our view no genuine knowledge of reality is possible, need not trouble us. If the facts force us to the conclusion that the perceived structure of the universe contains



an important subjective factor, we cannot be deterred by the consequences of our belief. Indeed, if the percipient mind only registered the objective world, could there be any important *psychology* of cognition? However, work such as that of Katz and Thouless on colour and size constancies, work already brought to the notice of this Section, proves sufficiently how autocratically the mind can deal with its sensory material. The more relevant psychological questions raised by recent developments of Gestalt-psychology are too large to be treated incidentally. It is enough here to express admiration for the persevering and ingenious research which they have stimulated. So to speak a little dogmatically, I hold that the mind informs its sensory material, making the percept consistent with certain subjective principles. This implies that the patterns of experience are in some sense already latent in the subject's mind as he confronts the world. Can we say how?

Alas, not very well. We must be content for the present with a small but useful advance to be made along the following path. If one says that perceiving is a response of the organism, meaning what one says, it follows that the distinction between cognition and conation is not an ultimate one. The general utility of the traditional division is not in question, but in the end we have to recognise that the process of coming to know is an activity, a piece of behaviour linked up with and subordinated to other behaviour. Conation *must* be the fundamental concept, because the first duty of every organism is to remain alive, and it needs to manage and control its environment to that end. Let us look for a moment at other forms of behaviour.

It is agreed that behaviour exhibits certain regularities of sequence which entitle us to formulate laws. In describing the phenomena the phrase which comes most readily to the tongue is that they exhibit patterns. The word has of recent years been very freely used. It requires no technical knowledge to understand the statement that a man's business activities show a constant pattern, no matter how varied the details with which he has to deal at different times. Our insight into the character of acquaintances mainly rests upon the observation of their behaviour patterns. It is very difficult to describe them, and still more difficult to analyse them, but they are easily recognisable. They are, in fact, the constancies without which social life would be impossible. The outstanding example of patterns of behaviour is presented by the instincts. In them we have themes which can be recognised as essentially the same while the details of the activity vary thoroughly, just as the theme of a symphony can be recognised through its development. But to say this is to apply the term 'pattern' as an objective description, and not as an explanation. Whether in this field you prefer to speak of urges and drives, or of fields of force and closure, is indifferent to the present argument, which requires only two points conceded to it: first, that these patterns of behaviour are observable, it being in virtue of them that the adjective 'instinctive' is applied, and, second, that the character of the organism is among the causes which produce them. We note that the behaviour of the human individual displays patterns which are similar in their outline to those of animals, and which, arguing from them, we must assert to depend upon the connate character of the organism.

To argue the obvious a little more fully, if a pattern is observable in behaviour, it must be dependent either upon the detailed events themselves, or upon the organism. In many cases, such as the behaviour of insects or nest-building in birds, there seems to be no sense in the first alternative, and consequently we take the patterns to be determined by the nature of the organism. This is to assert that the pattern is latent in the organism. But not after the manner of a blue-print. The latent pattern is not open to inspection. It exists, to use an old and respectable term, formally. There is a character of the organism which gives a distinctive pattern to its reactions. But there are also patterns observable in acquired activities, and in this case we have an everyday term to designate the quality of the agent which produces it. We call it a skill, and regard it as inherent in the subject whether he is or is not engaged in the activity at the moment. But once more it is not inspectable as the pattern of the activity is. All we can observe is that A by economical and coherent actions consistently achieves success in a given field, while B as consistently fails in it. Believing that all phenomena have a cause, we ascribe to A a skill which B lacks. So far as language goes, we can say either that A is skilled or that he possesses a skill. Both expressions are admissible, but I would suggest that the former is better in psychology, since we can neither observe, nor by deduction describe a skill in itself. When we attempt to do so we usually find ourselves describing again the pattern of the activity. Let us take a skill to be a character of the individual, a manner in which he has been psychologically shaped by racial or individual experience. To say that a person is skilled means that he is prepared to deal adequately with situations of a particular kind, but prepared in an outline, flexible manner which is sensitive to the varying details of the moment. Skill is in this respect on a higher plane than tropism, reflex or habit. The organism's skill is displayed in controlling and organising material on the way to achieving a goal.

Now we can return to our original problem of perception. No present-day psychologist can be content to regard perceiving as no more than reflecting the material world, or as a process to be studied in isolation. It is a preparatory reaction, prior to more far-reaching activities, its immediate goal being the organisation of sensory data into manageable forms. So we come to the conclusion that the predetermined 'ways of seeing' of which Rubin spoke to us belong to the vast family of skills, and can be treated with the others. The range of processes in which the pattern of behaviour, and the pattern resulting from the behaviour, depend upon the mental characteristics of the agent would appear to cover the whole extent of human life. At the London Meeting in 1931 I read a paper advancing the hypothesis that what is termed conceptual thinking can be dealt with in terms of skill, saying that what are termed concepts are best considered as outline preparations for response, and not as mental entities. I endeavoured to show that the behaviour of animals displays patterns parallel with those of a higher grade in human beings. I introduced the term schematic preparation, or more shortly 'schema,' as a name for this subjective character (1). Prof. Bartlett has also used the term, with greater profit than myself, and I quote from him a good statement of what the word is taken to mean. "“Schema” refers to an active



organisation of past reactions, or of past experiences, which must always be supposed to be operating in any well-adapted organic response. . . . There is not the slightest reason, however, to suppose that each set of incoming impulses, each new group of experiences persists as an isolated member of some passive patchwork. They have to be regarded as constituents of living momentary settings belonging to the organism, or to whatever parts of the organism are concerned in making a response of a given kind, and not as a number of individual events somehow strung together and stored within the organism' (2). This seems to me an excellent description of the growth of a psychological organism, emphasising that at all moments reactions are dependent upon the integrated effects of experience, which determine the character of the agent when confronted with any emergency. I see this living, momentary setting of the organism as the end-product of its history, and in so far as there is continuity in the settings they form a skill.

In once more advancing the views expressed in this address, maintaining the two points, first, that racial and individual experience results in schematic or outline preparation for future activity, thereby determining the pattern of the experiencing (for example, of cognising) and the pattern experienced (for example, the perceptual object cognised), and secondly, that these preparations or schemata are best regarded as modifications of the psychological organism, I do not pretend that I am stating anything very original, or greatly advancing science. But I am concerned to maintain that this line of thought is important because so unifying. In my earlier paper I applied it to thinking, and only hinted that the principle might be extended to other activities. Five years later, fortified by the parallel advance of Prof. Bartlett in another part of the field, I am bold enough to claim that our conception will cover all parts of animal and human psychology, pulling together into a system many heterogeneous results. The second part of my address will be an attempt to apply it in a department which I have not yet mentioned.

The most proper field for our study in Blackpool is obviously Social Psychology, and the Sectional Programme shows that the Organising Committee have recognised this. Can we apply the outcome of the previous discussion here? If not, my claims were invalid. So I was forced to undertake a new enterprise, passing from perception and thinking to a consideration of social behaviour. The term 'social pattern' is in common use, and perhaps is employed with dangerous facility. In the first place it appears to mean an observable system of relationships between individuals and their activities, constituting a unity of a higher order of complexity than that of any one of its members. Secondly, the social group is a part of the environment of each of its members and of persons who make contact with it from outside. It is a system of facts to which individuals have to adapt their behaviour. In this it is parallel to the inanimate environment, and since the principles of behaviour will resemble those already encountered the matter may be left for a moment at that level. Thirdly, social groupings present a puzzling combination of determinacy and flux. To live in society is rather like rowing in rough water. Within a quite characteristic pattern of the whole there is an inconvenient mobility of the elements, which requires continual varia-



bility of response. The patterns of society are determinate but dynamic, and to react successfully to them demands skill. To deal with this problem in a little more detail I turn to another paper read before Section J at Norwich, one by Prof. T. North Whitehead, since published in *The Human Factor* (3). A group of five girls working at the same tasks came in time to form a real social group with a complex but readily discernible pattern. An objective record of it was obtained by studying the relations between the output of individuals, and the writer was able to reduce these to a clear diagrammatic form. Since conversation is the chief instrument of social relationship, the seating arrangements proved largely decisive for the pattern. When an experimental change was made in the seating order the social and psychological pattern was broken and a new one had to be formed, output being adversely affected during the process. I hope that the memory of my hearers can carry them back to the curiously exciting effect of taking a new seat in the class-room, and the consequent disturbance of their work.

Prof. Whitehead's interesting report is concerned mainly with the objective study of the group. There are, however, important implications on the subjective side. In the first place, like everything else society is only apprehended by individuals, whose perception will be shaped in ways analogous to those revealed by Rubin in simpler material. This is the common handicap of all science, and no more need be said of it than to remind ourselves that each person must react to society as *he* sees it. A more important matter is that society, whose dominating influence we realise more and more, has proper significance for psychology only in its impact upon individual lives. It is, indeed, only actualised in those moments. Its components are individuals acting, and their behaviour is informed by the principles studied earlier. Yet their activities form a system, and we have to reconcile that with individual psychology.

A group only exists in virtue of conative tendencies developed by individuals in the course of accommodating their behaviour to each other's. It requires skill to live socially, and I see no reason why we should not treat this as we did others. Social skills are predetermined schematic preparations for adaptive responses to situations presented by the presence of other persons whose behaviour forms a reciprocally interacting system, and so it is the psychological character of individuals which chiefly determines the social pattern. I should like to adapt a famous conclusion of Rousseau, and say that society becomes a topic for psychology just because it exists immanently in the minds of its members. Whitehead's subjects did not build up a real unified group merely through the seating arrangements. The effects of the removal of the one who had become the leader show this. The unity of the group broke up, and though her successor became even more popular it was never fully reconstituted. So, at least, the writer maintains. But I venture to think that there was formed a new and firmly integrated pattern of a kind too subtle and intimate to be revealed by the test of correlative fluctuations of output. How otherwise can we account for the odd fact that when the former leader came back to replace her temporary successor the group was entirely broken up through the newly developed hostility to her, formerly the outstanding member of the group? What the experiment

depicts is the gradual orientation of individuals to each other—in other words, their learning ways of living with each other. When the social environment is changed a new set of behaviour tendencies has to be established, until in the final setting an environment was found to which the girls could not react successfully. But they had done so at an earlier stage, and we must conclude that in the intervening period some change had occurred in the other girls. The earlier objective conditions were repeated, but there was no unity. Can we avoid the conclusion that the unity had existed in the minds of the members, and those minds had changed to such an extent that the old reactions had become impossible? An objectively observable group pattern is a product of the skill-characters, or behaviour schemata, of the constituent members. So a problem of group psychology reduces itself to one of individual psychology.

Social patterns are largely manifested in institutions and current ideas, and often in combinations of the two. The English Common Law provides an excellent example of the last. This remarkable invention of our race has been maliciously described as consisting of a vast body of decisions and pronouncements, all readily deducible from a very few simple and universally accepted principles, though no one knows what they are. I cannot say whether this description is true, but there is no psychological difficulty in it. Common Law principles are the ways of living together developed by English people, and like all skills (for skills they are) they were developed in pursuit of ends which did not include the purpose of inspection. Pursuing a purpose and thinking about the pursuit are quite different processes. So for a long time, possibly always, they would not be amenable to analysis or description. To describe necessitates the development of a new skill directed to the material provided by the prior one. This is in essence Bartlett's illuminating distinction between schemata as the instruments of reaction and schemata as objects to which reaction is directed. The Common Law is the expression of the directive tendencies of citizens bent on living together along determinate lines, though they may have never reflected upon them. Probably the majority of Englishmen have never heard of the Common Law, though it governs their lives in so fundamental a manner. It is quite usual to find that people who evince a great determinateness of behaviour are unaware of the principles which govern them. Why should they pause in the process of achieving their ends, if all is going well, to 'turn round upon the schemata' which are serving them?

There is a danger in any form of expression which suggests an opposition between Social Psychology and Individual Psychology. The field marked out by the former term is one proper for the specialist, but it remains the study of individuals acting socially. It would avoid the risk of over-abstraction, with possibly something of mysticism arising from it, if we were satisfied to speak of the psychology of social behaviour. At bottom it is the study of the development and nature of schemata employed in orientation to other behaving organisms. They, too, act from schemata, and if they are to live together they must effect a considerable degree of uniformity. So the social pressure upon individuals is intensified by the establishment of institutions which are the outward patterns resulting from the psychological characteristics of the members of the group, and in return a potent means of shaping the next generation. Here the vital



problem of society resembles that of the individuals (as must be the case). It is that of keeping the outline preparations for adaptive behaviour sufficiently fluid to be sensitive to variations in the problems presented. The Hegelian limit of efficiency is inflexible specific habit, which is a skill so perfectly developed as to become a hindrance.

Ideals as well as institutions express the developing patterns of society. Can we suggest a psychological treatment of ideals? It seems to me that an ideal is a schema of behaviour made sufficiently inspectable to receive a name. Probably it is never made completely amenable to description. Our own difficulties in attempting to discuss our ideals, together with the fact that there is obviously something in us which we feel we must explain to others, prove that their mode of existence lies deeper than the level of language behaviour. But not only can few men state their ideals adequately and many not at all, it is not necessary that they should be so expressed. No one should be described as without ideals merely because he is not sufficiently aware of them to call them by name. It is more charitable, and better psychology, to deduce the ideals from the prevailing patterns of his behaviour. I suspect that the underlying fabric of ideals suffers at times from premature display or too zealous propaganda.

Now to summarise briefly the thread of this discussion. The subject-matter of psychology is taken to be the activities of the individual organism striving to maintain its full integrity in the universe in which it lives. To obtain control it must organise the presented material of experience into patterns manageable by it, and to this end it develops skills in its activities. Naming these skills by a word not inconvenienced by over-much usage, we have called them schemata, and the system of a person's schemata embodies all his experience up to the present moment, and determines the direction of his future experiencing. The patterns of experience are formed by them, though not independently of objective conditions. Thus in outline the 'ways of seeing' and the 'ways of living'—whether socially or otherwise—are reducible to a common psychological genus.

I have already disclaimed any pretence that this view offers a great addition to the content of psychology, and it is at present too sketchy to be called a theory. I have given, as I said at the outset, a profession of faith, just one way of seeing psychology. Its value to me lies in its providing a unitary point of view from which, it is hopefully claimed, one can survey the whole extent of psychological study. At least it may prevent a born eclectic, like the present speaker, from degenerating into a kind of scientific jackdaw. So I invite you to regard experience, in the fullest sense of that word, as formed in a complex of patterns largely made by the experiencer, patterns in some cases interlacing, in others forming a hierarchy of increasing generality. Or, to start from the other end, let us take our science to be the study of all the detailed embroideries upon that most common and most comprehensive of patterns, the formula of which runs: He was born, and strove to master his world for his own safety; he mated, fought for his offspring, and died.

#### REFERENCES.

- (1) 'On Conceptual Thinking' (*British Journal of Psychology*, xxiv, 133-143).
- (2) *Remembering*, p. 201.
- (3) 'Social Relationships in the Factory' (*The Human Factor*, ix, 381-394).



## SECTION K.—BOTANY.

# THE USES OF FUNGI

ADDRESS BY

J. RAMSBOTTOM, O.B.E.,

PRESIDENT OF THE SECTION.

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IN considering a subject for this Address I was attracted by certain aspects of Botany which, though mentioned incidentally, if at all, in academic teaching, play a major part in general botanical activities. But, finding that I was expected to deal with Mycology, I chose a topic which seemed to fit in with the Council's suggestion that some aspect of science should be treated which had a bearing on the life of the community.

All who have paid any attention to fungi realise the vast amount of disease and damage which they cause. Fungal diseases of plants and animals, fungal damage to stored products, to timber and to food and the search for Hæmony 'of sov'ran use 'gainst all enchantments, mildew blast, or damp, Or gastly furies apparition' have frequently been discussed, but there seems to have been little consideration of how fungi enter generally into problems of life and existence. Every schoolboy knows that life as it is would be impossible without chlorophyll; but it is often overlooked that unless there were also organisms without chlorophyll, plant and animal life would cease. The fact that fungi lack chlorophyll imposes on them their several ways of physiological existence which have results so important to man. Colourless bacteria though having a similar physiology do not fall within the scope of this address.

Presumably it has always been known that some of the larger fungi are edible and some poisonous. In this country it is not common knowledge, however, that only half a dozen or so are poisonous. The rule of thumb methods for distinguishing between edible and poisonous species are worse than useless, for *Amanita phalloides*, the most poisonous of all fungi, 'peels,' does not turn a silver coin black, nor does it obey any of the rules which have been in common practice since classical times. Accidents are certain when there is indiscriminate eating of anything, and fungi are no exception. Though the consumption of the common mushroom appears to be increasing there is little sale now for any other species in the ordinary markets. Blewits (*Tricholoma personatum* and its allies) is sold in the north, midlands and west; I have known it to be seized as poisonous when offered for sale in the south. Occasionally one sees *Boletus edulis* and *B. scaber* on barrows in the streets of Soho, and

various species figure in side-dishes in the restaurants—but the customs of Soho are as alien as its inhabitants.

I can find no evidence that fungi were ever eaten here so extensively as in many parts of the Continent, where there are special markets, with their own lists of edible fungi and their inspectors, some of whom have made valuable contributions to mycological taxonomy. But the attitude of a country may change in these matters. Berkeley wrote in 1857 that 'the prejudice against Fungi is so great at Paris, that artificially raised mushrooms are almost the only ones of the genus that are admitted into the market, and in London the number is confined to about six.' Yet in 1670<sup>1</sup> the French were apparently as fond of mushrooms as they are to-day. In Sweden, where many species are sold in the markets, the much esteemed *Boletus edulis* is called Karl Johannsvampen after Jean Baptiste Bernadotte, Napoleon's Marshal who was chosen heir to the Swedish throne. He assumed the name's Charles John, and afterwards became Charles XIV; he is said to have introduced fungus-eating to his new country and cèpe was his favourite.

Fungi form the main food of the poorer classes in the Baltic States,<sup>2</sup> and in the vast tracts of marshy land in north-east Russia at certain times of the year, and it will be remembered that Darwin records that, except for a few berries, *Cyttaria* is the sole vegetable food of the natives of Tierra del Fuego.

There are suggestions in classical writings about methods of producing edible fungi. One which was adopted and which has been carried on until the present day is the watering of old stumps of poplar to stimulate the growth of *Pholiota aegerita*. Similarly watered, the mass of earth compacted together with fungus mycelium—the fungus-stone, lapis fungifer, coveted by Pepys, and which puzzled and interested Goethe—produces the edible fruit-body of *Polyporus tuberaster* known since the fourteenth century and mentioned by several of the herbalists; its classical locality is Italy, but it doubtless is the same as the Canadian Tuckahoe (*Grifola* [*Polyporus*] *Tuckahoe*). The pseudo-sclerotium, with its included tufa, soil or stones, is not itself edible, and thus differs from the true sclerotia, composed entirely of fungal mycelium, of several other species. Amongst these the best known are: *Poria* (*Pachyma*) *Cocos*, the Tuckahoe or Indian Bread of America, which occurs associated with the roots of pines and other trees apparently as a weak parasite—it is probably the same as *Pachyma hoelen*, the Bukuryô of Japan and Fuhling of China, used in oriental medicine for four thousand years, with a primitive cultivation and an export as Chinese Root of over one thousand tons annually; *Polyporus Mylittae*, the Blackfellows' Bread of Australia, and various tropical species of *Lentinus*, of which the first known was the *Tuber regium* of Rumphius.

The only larger fungi which are cultivated to any extent by man are

<sup>1</sup> 'I hoped milder physick might cure them of this French disease, of this inordinate appetite to mushrooms.'—*The Memoirs of Monsieur du Vall*.

<sup>2</sup> Letts are often to be seen in Epping forest, where they gather large quantities of almost every species and pickle them. French, Italians and Swiss met in the woods of the home counties are usually making special search for species of *Boletus*.

the Field Mushroom (*Psalliota campestris*), the Shiitake (*Cortinellus Shiitake*) and *Volvaria volvacea*, but it is of interest to note that here, as in some other directions, the ant, regarded by some as man's most serious competitor, has succeeded in cultivating many more fungi in its fungus-gardens; the termite, more an enemy of man's social progress than his competitor, also is a fungus-cultivator.

The common field mushroom is cultivated in Europe and America. It has long been valued for its esculent properties. Horace referred to it—'pratensibus optima fungis Natura est aliis male creditur'—which Gerard translates as 'the meadow mushrooms are in kind the best, It is ill trusting any of the rest.'

When and where the cultivation of the mushroom began is unknown. Tournefort in 1707 writes as if it was then grown commonly in France and it is probable that the methods he described were of French origin. It is not difficult to imagine how the frequency of mushrooms in horse-tracks and other highly manured places led to a realisation of the requisite conditions of growth, but it was fortunate that the mushroom was tried, for no attempt since made to cultivate other species has met with commercial success. Without entering into details it may be said that the methods described by Tournefort are essentially the same as those followed at the present time with the exception that spawn was not planted in the beds as it was thought to occur spontaneously in horse-dung in sufficient amount. Later the practice arose of inoculating the beds with virgin spawn which, in this country, was usually contained in mushroom 'bricks,' masses of dried horse-dung permeated with fungus mycelium. The virgin spawn was obtained from highly manured places, mill-tracks, stables, under haystacks, or even from trenches specially prepared with layers of horse-droppings. Spawn-gatherers were highly skilled and able to distinguish mushroom-spawn by its smell and appearance from that of the numerous coprophilous fungi with which it is associated in natural conditions. Since the War, however, the spawn-gatherer of the old type seems to have disappeared almost as completely as the professional truffle-hunter. The chief reason for this is that spawn is now produced commercially by scientific methods.

So soon as it was understood that fungi were reproduced by spores attempts were made to obtain spawn from them. Though these efforts may be said to have begun with Micheli's experiments on various fungi in 1729, it was not until 1894 that J. Constantin and L. Matruchot succeeded. They patented their method and the process was carried out for some time at the Institut Pasteur where there was a 'Service des blancs de Champignons' under the direction of M. Tellier. Meanwhile interest was aroused in America, which was importing about 3,000,000 pounds of canned mushrooms annually, and growers, moreover, had to depend upon foreign spawn. The United States Department of Agriculture began experiments. M. C. Ferguson carried out research work on spore-germination but had little or no success except when a small piece of mycelium was present. B. M. Duggar, who had been in Europe studying methods of cultivation, described in 1905 how spawn can be obtained satisfactorily by making cultures from the flesh of the stipe, an application



of a common laboratory-method of obtaining growth. It is directly owing to Duggar's investigations that the mushroom-growing industry began its great development in America, where the annual production is now 17,000,000 pounds.

At the present time several firms in this country produce spawn. This so-called pure-culture spawn may be tissue-spawn or spore-spawn—it is not possible to judge from some of the advertisements. Most of the spawn on the British market is produced either in this country, in America, or in France; it is sold in bottles, cartons and other receptacles and very little brick-spawn is now used. All firms keep their methods secret, but it is said that while some germinate the spores as shed, others use the flesh of the stem, or gills. It may seem an anticlimax to add that the secret surrounding the germination of mushroom spores is simply a time factor, for they will grow on a wide range of media if sown fresh and left for from ten to fourteen days.

By the adoption of the pure-culture method it is possible to perpetuate a satisfactory strain and this will remain as true as that of any horticultural plant. Thus a good deal of the former indefiniteness about the crop to be obtained is obviated. But judging from the displays in London shops there are too few strains now grown. It should be possible and profitable to get away from the three or four stereotyped forms, one at least of which appears to be American.

With the coming of the motor-car there was immediately a fear of a shortage of manure for making mushroom-beds, and it cannot be said that the danger has decreased with the years, now that even cavalry is being mechanised. The attention of scientific men and growers is being paid to the possibility of a substitute, but so far with no outstanding success.

Mushroom growing is not an easy business if it is to be carried on year after year. There seems to be a popular idea that mushrooms can be successfully grown only in darkness, and that sheds, tunnels,<sup>3</sup> caves and suchlike must be available. It is true that caves—if properly ventilated—are very satisfactory as is abundantly proved by the outstanding results obtained by French growers in the famous caves in the environs of Paris.<sup>4</sup> However, it is rare to find mushrooms growing naturally in anything but full daylight, and a good deal of commercial growing is carried on in the open in the south-east of England. Indeed at the time of the first development of the sites of the South Kensington Museums the neighbourhood was well known for the mushroom crops of its market gardens.

The Japanese and Chinese are great consumers of fungi, and many species, fresh, dried or canned, are on sale in the shops. The most appreciated species in Japan is *Cortinellus edodes*, 'Matsu-dake,' and annual picnics are held for gathering it in the *Pinus densiflora* forests, an age-long custom frequently alluded to in poetry and in pictorial arts.

<sup>3</sup> The best known of these in the British Isles is the Scotland Street Tunnel at Edinburgh.

<sup>4</sup> The cultivation of mushrooms is now carried on in the caverns under Hamlet's palace, Kronenberg, at Elsinore.

One species, 'Shiitake'<sup>5</sup>—*Cortinellus Shiitake*—is cultivated, 2,000,000 kilograms being produced annually, of which 700,000 kilograms are exported, valued at £100,000. The primitive method of cultivation, which is said to date back more than a thousand years, was merely to make a pile of logs in moist, shady places in the forest. In modern practice the logs are inoculated with powdered infected wood, or with spores of the fungus shed on the mats used during drying and mixed with sawdust, or with macerated sporophores. These are inserted in the log and the holes or incisions covered with leafy branches or with wet straw-mats.<sup>6</sup> There are two crops a year. S. Mimura states that as a result of more scientific methods there was an increase of over twenty per cent. in production in about ten years.

As the climate of Japan where Shiitake flourishes is much like that of Central Europe, H. Mayr of Munich attempted to introduce the fungus and its culture. Though his experiments, which began in 1903, were carried on for ten years or so they met with only partial success.

More recently F. Passecker has succeeded in growing the fungus in pure-culture up to the fruiting stage.

The Chinese in Formosa have long valued as food young shoots of *Zizania aquatica* (Canada rice) infected with *Ustilago esculenta*. The mycelium of the smut is perennial in the rhizome, so that when infection has once taken place the grass produces hypertrophied shoots each year. Before spore-formation the hyphal mass is white and compact, and at this stage is sold in the markets as 'kah-peh-sōon,' 'white bamboo-shoot growing on the wild rice plant.' Cultivation is carried out along roadsides and in small gardens. The ripe black spore-powder was formerly sold on the mainland of Japan and was used 'to paint eyebrows and borders of the hair by ladies or actors and sometimes used as medicine.'

The third fungus mentioned, *Volvaria volvacea*, is widely cultivated in the tropics. This species occurs in Europe, but is somewhat uncommon, being found for the most part on tan in glass-houses. It is rather remarkable that until a few years ago all species of *Volvaria* were considered poisonous, possibly owing to comparison with *Amanita phalloides*. The wide extent of the cultivation of *Volvaria volvacea* is only now becoming realised, although Rumphius so early as 1740 mentioned the fungus under the names *Boletus moschocaryanus* and *B. sanguineus*. In recent literature it usually appears as *Volvaria esculenta* Bres. (1912). The first detailed account of its cultivation came from the Philippines, but the general methods are followed also in Java, Indo-China, Madagascar, and West Africa. Heaps of vegetable refuse—rice-straw, sugar-cane bagasse, chopped banana trunks and leaves, husks of coffee and nutmegs, refuse from citron oil, sago or indigo manufactories—are built in shady or damp places in abaca and banana plantations or in old overgrown wood-lots.

<sup>5</sup> 'Shii' is the Japanese name for *Pasania (Castanopsis) cuspidata*, 'take' means a fungus. The fungus grows also on *Quercus* and other Fagaceæ.

<sup>6</sup> There is a similar practice in the mountains of parts of Foochow. 'Incisions are made in the logs, liquid manure is poured over the incisions, straw is covered over them, and when this is well rotted the fungi spring forth.' (J. Arnold, quoted in *Philippine Edible Fungi*, by O. A. Reinking). Foochow is the centre of the Chinese dried-fungus trade.



The heaps are not inoculated artificially. They are watered, sometimes with brine rice-wash or the scum of sugar-cane juice and last for some time, usually bearing after about a fortnight. Because the fungus occurs on ant-hills and on fallen wood and decaying plants after rain, which is usually accompanied by thunder and lightning, the Philippine natives call it 'The flower of thunderbolts and lightning': it will be recollected that the Greeks similarly accounted for the formation of truffles.

Truffles and morels have always been highly esteemed, and numerous attempts have been made to grow them as a crop, but so far without success. Some of the methods reported at different times as successful remind one of a belief formerly common among English farmers that mushrooms are produced by salt. To judge from official correspondence there is at present a keen interest in the possibility of growing truffles on a commercial basis in this country; there would be a ready market for them at high prices. It seems worth noting that *Pseudobalsamia microspora*, one of the Tuberaceæ, is a common invader of mushroom-beds in America; it has recently been recorded for this country.

From time immemorial truffles have been hunted by pigs, dogs, and more rarely goats. The truffles which are on sale in London shops<sup>7</sup> are chiefly the Périgord truffle (*Tuber melanospermum*) though *Tuber brumale* is occasionally seen. The white truffle of Piedmont (*Tuber magnatum*) apparently is not exported. Closely allied forms, terfas or kames (*Terfezia*), are commonly sold in the native markets of north Africa, and one species, *T. leonis*, is an article of commerce in south Spain and Portugal.

It is now often overlooked that species of edible truffle occur in this country, but fifty years ago English-gathered truffles were on sale in Covent Garden. Dogs were used to hunt them in Wiltshire and Sussex until just before the War. Here it may not be out of place to mention that it was owing to truffles being found in Wiltshire that British mycology gained one of its most valuable recruits. C. E. Broome was living at Rudloe, Wiltshire, in 1841, when on the advice of Leonard Jennings he sent an alga to the Rev. M. J. Berkeley for naming and two sketches of moulds. Berkeley asked him whether truffles were found in his neighbourhood. Broome succeeded in finding some, and, his appetite being whetted, he enthusiastically searched for them for the rest of his life, never being without a rake on his travels. He found several species new to science, and added many to our fungus-flora, being the only British mycologist who has had any success in this direction. He collaborated with Berkeley, being responsible for most of the drawings and measurements of microfungi, and from 1848 to 1886 they worked so assiduously that the authority 'B. & Br.' is one of the best known in taxonomy.

To round off the story, mention should be made of the use of poisonous fungi. The intoxicating effects of *Amanita muscaria* and its uses in the religious rites of certain Siberian tribes, as well as for killing flies, are well known.

The historical accounts of the poisoning of priests, poets and kings,

<sup>7</sup> France produced 200,000 kilos of truffles in 1933 at a total value of over 13½ million francs; 92,700 kilos were exported fresh, dried or marinated.



do not clearly distinguish between the putting of poison into the dish and the presence therein of a poisonous fungus whether by accident or design.

With the widespread knowledge of poisonous fungi on the Continent it is surprising that little criminal use appears to have been made of them, especially as the writers of modern detective stories have shown their possibilities. However, a case which aroused great interest in France towards the end of the War was that of an insurance agent, Girard, who was executed in 1918 for making use of his mycological knowledge and his professional opportunities as an insurance agent to get rid of a number of clients, the second batch by means of *Amanita phalloides*. But this was simple compared with a habit of the Watusi of the Victoria Nyanza region. G. Mattlet describes how, when they wish to wreak their vengeance on anyone, they exhume the corpse of a person who has recently died of pneumomycosis. They remove the lungs, dry and powder them, and administer this in banana beer. The fungus survives the treatment.

As would be expected man has contrived to make use of the larger fungi in many and various ways, a few only of which need be mentioned. From the earliest times the sterile bases of puff-balls have served for staunching wounds ;<sup>8</sup> *Lycoperdon Bovista* is the *Bovista officinalis* of older works and 'summopere laudata' as Vittadini says. Within recent years it has been proposed to use it as a styptic in veterinary work.

The soft flesh of certain species of *Fomes*, particularly *Fomes fomentarius*, has been employed for many purposes. As amadou it was formerly used as tinder after beating and treatment with saltpetre ; it is still used by dentists for absorption and compressing, by fly-fishers to dry fly, and in some types of experimental pneumatic fire-syringes. Caps, aprons, picture-frames and such-like made from it are still common in Thuringia and the afforested parts of Germany. It was with this 'Touch-wood . . . commonly call'd by the name of *Spunk* ; but that we meet with to be sold in Shops, is brought from beyond Seas' that Robert Hooke made the first known observations on the microscopical structure of fungi in his *Micrographia* (1665). The account occurs in Observation XXII—Of common Sponges, and several other Spongie fibrous bodies—and so is likely to escape notice : 'The substance of it feels, and looks to the naked eye, and may be stretch'd any way, exactly like a very fine piece of *Chamois* Leather, or wash'd Leather, but it is of somewhat a browner hew, and nothing neer so strong : but examining it with my *Microscope*, I found it of somewhat another make than any kind of Leather . . . it consists of an infinite number of small filaments. . . .'

The luminosity of fungi is one of those strange natural phenomena which always arouses interest, and there are many accounts of it. Miss L. E. Cheesman informs me that on her recent visit to the New Hebrides she was bushed one night and, passing near a village, said she must have a light. Boys collected a luminous fungus with a glutinous cap which they stuck all over themselves. She could then see a column

<sup>8</sup> Cf. Romany couplet : 'Quanda mandi chivs moilee Ke vindi morripude,' When a man cuts his fingers, he uses the puff-ball.

of boys trailing through the forest. This account recalls one which Olaus Magnus gave in 1652 of the way in which luminous fungi and wood are arranged at intervals through the forests of remote countries of the north. Sometimes only the fruit-body is luminous, sometimes the mycelium also, sometimes the mycelium alone; in these last the wood affected also is luminous, and this caused some concern occasionally in the early days of the War, when townspeople had to learn to move about in the dark out of doors. It had its uses sometimes in the trenches to prevent collisions; and Ben Jonson refers to one which does not appear to be practised—'While she sits reading by the glowworm's light, Or rotten wood, o'er which the worm hath crept.'

G. H. Bryan in 1923 recommended the use of the 'inky juice' of *Coprinus comatus* for retouching or painting out defects in photographic negatives.

Hottentot ladies use the spores of *Podaxis carcinomalis*, which grows on ant-hills, as a face-powder. Miss E. L. Stephens, who told me of this, says that the spore-colour suits their special complexion. This is equalled by an account of the examination of 'An European Mummy,' from a Roman cemetery near Budapest, which is best given in the original.<sup>9</sup> 'As I examined the contents of the boxes I found by mikroskopical way, that they contained the face powder of the women prepared of a mixture of rice-flower and the reddish brown spores of the mushroom *Tolyposporium junceum* added evidently with the purpose to diminish the white colour of the rice flour. As powder puff served a piece of sponge.'

It is puzzling to know what is behind the fact that John de Warrenna (ob. 1347), Earl of Sussex and Surrey, held the manor of Gymyngnam (Gimingham, County Norfolk) by the rendering to the King a mushroom (campernolle) yearly.

We are so accustomed to think that wood attacked by fungi is worthless that mention may be made of two or three examples to the contrary.

The wood of birch infected with *Polyporus betulinus* is powdered and used for burnishing watches in the Swiss watch industry. The soft flesh of the fungus served our ancestors for making razor-strops; entomologists use it for pinning insects.

The well-known 'green wood' of Tunbridge Ware is usually oak or birch (though other deciduous trees are affected) containing the mycelium of *Chlorosplenium aeruginosum*. The mycelium, as well as the fruit-body, is a brilliant green and colours the wood. Thin strips of different coloured woods are assembled into blocks so that their ends form the pattern or picture required. The woods are glued and bound together under pressure. When set, thin slices are cut across the block with a circular saw. The slices show the pattern, and are glued on the table, box, or other object to be decorated, carefully smoothed off and polished. The art which died out for some years in Tunbridge Wells has recently been revived.

Some of the decorative wood which is occasionally seen is ordinary wood infected with some fungus, such as *Armillaria mellea* or *Ustulina*

<sup>9</sup> F. Hollendonner in *Magyar Botan. Lapok*. XXXII (1933), 107.



*vulgaris*, which forms a black line at the limit of its attack. As these lines bear no relation to the normal orientation of sectioning, peculiar patterns often result. When tempted to purchase furniture so marked it is always advisable to test the wood in the neighbourhood of the line for defect.

The type of oak known as 'brown oak' is much valued by timber merchants. K. St. G. Cartwright has recently shown that though the wood is structurally sound, the colour results from the attack of the common beef-steak fungus, *Fistulina hepatica*, and further, that the colour can be produced by artificial inoculation with the fungus.

The destruction of logs by fungi is one of the important factors in the life of a forest. It is strange to learn of rotting wood being sold at a fairly high price as cattle food. On Chiloe Island off the coast of Chile and in eastern Patagonia the wood of various trees such as *Eucryphia cordifolia*, *Weinmannia trichosperma*, and species of *Nothofagus* is converted into a palatable food (palo podrido) by a mould, *Mucor racemosus*, in conjunction with bacteria. The smell and taste of the altered wood is said to resemble somewhat that of fresh mushrooms: it forms a valuable addition to pasturage.

It is not surprising that fungi formerly were held in high esteem as cures for various ailments. Ergot (*Claviceps purpurea*) is the only one which is retained in the British Pharmacopœa. It was not known to classical writers and the beginnings of its history are in German folk-lore. The fungus attacks many species of grass, but is principally known from rye. Periodically, but more particularly in the middle ages before the effects of famine were neutralised by rapid transport, outbreaks of ergotism caused plagues of sufficient severity to be recorded. Two main types of ergotism are recognised, gangrenous and convulsive. The last great epidemic occurred in Russia where from September 1926 to August 1927 over 11,000 cases became known to the authorities. A mild epidemic was reported at Manchester in 1927 among Jewish immigrants from central Europe who lived on rye-bread. The use of ergot in midwifery began in the eighteenth century in France, Germany and Italy, but its entry into official medicine took place in the United States early in the nineteenth century. An enormous amount of pharmacological investigation has been carried out, and recently A. McCrea has shown that the fungus grown in saprophytic cultures produces the three chief active principles (ergotinine, histamine and tyramine), characteristic of the extracts made from natural sclerotia, in sufficient amount to be of economic importance.

The two main sources of ergot are a large region in eastern Europe (chiefly Russia and Poland) and a smaller one in the moist north-west corner of Spain and Portugal, though other countries produce enough for their own use. The size of the crop varies from year to year, the average for a number of years being about a hundred tons from Russia and seventy tons from Spain.

From the time of classical writers Agaricum, or Female Agarick, has been used for many ailments. Dioscorides believed it to be the most efficacious of all agencies in curing disease, and gives a list of its virtues



which reads like an advertisement of a modern patent medicine. It is the dry, white, friable flesh of *Polyporus officinalis* which grows on larch in subalpine regions ; it has not yet gone completely out of use.

Similarly, yeast was prescribed medicinally by Hippocrates and later by Dioscorides, and it is still used for various ailments and incorporated in many patent medicines.

The list of fungi employed as medicines by natives in all parts of the world is very long, and its chief interest lies in the beliefs associated with many well-known species. One of the most celebrated is *Cordyceps sinensis*, with its attached parasitised caterpillar, which is sold throughout China in bundles tied up with red silk. Captain Kingdon Ward tells me that coolies collect this in the south and east of Tibet and that his own men are always on the look out for it.

One aspect of the general subject which must be dealt with very summarily is that of mycorrhiza. It will be well to treat of orchid-growing, because there we meet with the best example of a practical application. It has been known for almost a century that fungal hyphæ are present in the roots of orchids as they are, as a matter of fact, in those of many other families. Such difficulty was experienced in germinating the minute seeds of orchids that for many years it was thought of sufficient interest to describe and illustrate any seedlings which were obtained. The first practical step which proved of value was that of sowing the seeds on the soil of the pot containing the parent plant, a method apparently introduced by Neumann in 1844. There were modifications of this method, and gradual progress was made, but what success there was could be attributed rather to the 'green thumb' of the grower than to any essential difference in procedure. At the beginning of the century, Noel Bernard, as a result of his study of *Neottia*, the bird's nest orchid, realised that the presence of the fungus in the root was in some way connected with the difficulty of obtaining seedlings, and astounded the botanical and horticultural worlds when he extracted the fungus from a root and, sowing seed with it, obtained abundant germination. The method has been used on a commercial basis in France, Germany and this country.

Following on some experiments by Bernard, L. Knudson has shown that the action of the fungus can be replaced by sugars in the medium. This so-called asymbiotic method has also been employed in commercial orchid growing. Here we have the reverse of what is the common sequence, i.e. a fungus is proved to be necessary to bring about a desired end, and, as a further step, the action of the fungus has been replaced by chemical means. So far as my experience and observation go, the purely chemical method is not so satisfactory as the symbiotic method, though as germination in both is carried out in culture-flasks there seems no theoretical reason why there should be more than a temporary difference in the first stages. It may be added that the first orchid firm to apply the pure-culture method in this country has followed it for a quarter of a century, and for many years germination has been regarded as a routine requiring no scientific supervision.

Most, if not all, forest trees have mycorrhizal roots, though the relation

between the fungus and root is not of the same general type as in orchids. Trees growing under certain conditions undoubtedly benefit from the presence of the fungus, and forestry research-workers are investigating the problem of artificially infecting seedlings with appropriate fungi. Food obviously passes from the mycorrhizal fungi into the tree roots whether the food is absorbed from the fungus itself or is formed in the soil by the action of the fungus on substances present there.

Fungi are able to bring about changes by means of enzymes, and it is surprising what veritable museums of enzymes many fungi are, e.g. from *Aspergillus Oryzæ* the following have been recorded: amidase, catalase, cytase, dextrase, diastase, emulsin,  $\alpha$  and  $\beta$  glucosidase, glycerophosphatase, histozyne, inulase, invertase, lactase, lecithinase, lipase, maltase, protease, rennet, sulphatase—apparently sufficient for any purpose here below

It is puzzling why with such a battery of attack many fungi are not more nearly omnivorous; obviously other factors in addition to enzyme action enter into the problem. One thing is sure—there are abundant species and there is abundant decay. But all decay is not destruction, and life—so long as it remained possible—would be odd without the changes brought about by fungi.

From earliest times man has made use of the action of certain fungi for bringing about desired changes in food and drink. More recently many of these processes have been carried out under controlled conditions, and other fermentations have been harnessed by man for his need, his pleasure, or his convenience. Fungi are rapidly becoming more important in this respect, and we may anticipate an increasing number of industrial applications of fermentation activities. There is every sign that eventually we shall have a great chemical fermentation industry producing many substances which are now manufactured by expensive synthetic methods, for many such substances are known to occur as metabolic products of micro-organisms. Regarding the formation of these products, A. J. Kluyver writes: 'Even a superficial survey of the biochemical field is apt to fill one with profound astonishment at the practically unlimited diversity of the chemical constituents of living organisms. But this astonishment is transformed into bewilderment when we take into consideration the chemical processes which lead to the formation of these various products. For we have to accept the undeniable fact that all these substances have ultimately been derived from carbon dioxide and inorganic salts by a more or less elaborate series of biochemical processes. . . . Here we find the most remarkable fact . . . that a single organic compound suffices to ensure a perfectly normal development of these organisms, although they are cut off from any external energy supply. Here we find the biochemical miracle in its fullest sense, for we are bound to conclude that all the widely divergent chemical constituents of the cell have been built up from the only organic food constituent, and that without any intervention of external energy sources. The chemical conversions performed by these organisms rather resemble witchcraft than chemistry!' The Great War stimulated much research in these problems, and some of the methods then devised have been improved and extended just as Pasteur's studies



on beer, undertaken as an immediate result of the misfortunes which befell France after the Franco-Prussian War, led to a scientific method of brewing. It has been said that when we can convert our evening paper into sugar so rapidly that we are able to eat for breakfast the albumen prepared therefrom, then indeed shall we have solved one of the greatest problems of the century.

It is easy to suggest how some of the early important social discoveries in fermentation were made, but Elia has immortalised the essentials of all such hypotheses; the aim of science is to confine within reasonable limits the stage which corresponds to the burning down of the hut.

Most of the older processes depend upon the action of yeasts, i.e. fermentation in its restricted sense, the conversion of sugar into alcohol and carbon dioxide. They make a formidable list, and it is not necessary to refer to any but the more important or more interesting.

Bread has been made since prehistoric times and leavened and unleavened bread were clearly distinguished in the Divine instructions for the first Passover. Leaven is a portion of dough left over from the previous baking, and French bakery had its sequence from *levain de chef* to *levain de tous points*. The 'sour dough' was presumably the experienced pioneer who saved a little of his previous bake. It was a great step forward when brewers' yeast was first used in baking in the early eighteenth century. The purpose of fermentation is the effective aeration of the dough by the uniform dispersion of carbon dioxide which must be occluded and retained by the gluten so that a well-risen loaf will result on baking, of required volume, texture and flavour with no alteration of the wheat protein. This fermentation is now accomplished by compressed-yeasts of pure-culture strains physiologically adapted to rapid and abundant gas-production in the complex environment of the dough. The compressed-yeast industry has gradually become more scientific since its introduction about 1860. For forty years or so the Vienna process of low aeration was practised, but this has been long replaced by higher aeration methods. The employment of compressed-yeasts has supplanted the older methods of using leavens, barm, ferments and brewers' and distillers' yeasts except where special types of bread are required, but even here biological culture materials are coming into use as for the fermentation of sour-rye dough. Chemical methods of aeration such as by carbon dioxide under pressure, or as the result of reaction of substances in the presence of water, have fallen into disfavour except in biscuit manufacture, cake mixtures and self-raising flour. In ordinary circumstances it is essential that the yeast shall be used fairly fresh, and in England supplies are distributed to every town and village three times a week. During the General Strike of 1926 the Board of Trade had an emergency organisation which kept up the regular supply from Scotland and Ireland. The amount of bakers' yeast produced in Great Britain in 1930 was 2,200 tons with a value of £916,000.

The changes which take place in the juices of fruits doubtless were known before the fermentation of cereals. Certainly by the time man's speech became coherent he sang the praises of wine as is seen in the numerous references in Egyptian hieroglyphics, Babylonian cuneiform



inscriptions and the manuscripts of Greek mythology. The yeasts bringing about the fermentation of the grape sugar when the juice (must) is pressed out are present on the skins of the fruit: they winter in the soil. Different forms of yeast occur in different vineyards, though they are usually of the *Saccharomyces ellipsoideus* type. The character of the wine depends upon the kind of grape and the manner and period of fermentation: red wines are formed when the colour from the skins is extracted by the fermented liquor. Brandy or cognac is the alcoholic distillate from wine.

In fermentation processes it is common to find that a practice handed down from antiquity was carried on in essentially the same way until recent times, and then there has been some method of control. Naturally in so important an industry as wine-making—e.g. France devotes four million acres to vineyards—scientific methods have been widely adopted. It is a little too haphazard to depend upon the naturally occurring yeasts on the grape skin. Consequently the skins are sterilised either by Pasteurisation, or more commonly by the addition of a small amount of a dilute solution of sulphurous acid or one of its salts, generally potassium metabisulphite. Pure-culture yeast is added to the must as a 'starter.'

As fermentation is carried out in the open it is obvious that other yeasts enter the fermenting liquor. *Mycoderma vini*,<sup>10</sup> 'la fleur du vin,' is active in bringing about the ageing of sherries kept on ullage, by inducing oxidation changes and esterification. In some districts of France, *Botrytis cinerea* is allowed to infect grapes which are to be used in making wine of relatively high alcohol content (e.g. Sauterne), which usually contains some unfermentable sugar. This 'noble mould' produces no objectionable odour or flavour; its growth merely results in considerable loss of water from the grape.

The preparation of cider and perry is similar to that of wine. Formerly the juice of apples or pears when pressed out of the pulp was allowed to ferment with the yeasts occurring naturally on the surface of the fruits. Modern manufacturies, however, use pure-cultures of appropriate yeasts, which enable them to standardise their products in a manner not possible if reliance is placed on the mixed natural population.

Mead is sometimes regarded as the oldest beverage of the human race, for it was probably brewed from the washings of emptied honeycombs before crops were cultivated. It is still made in English farmhouses, and sold to a small extent on the Continent. Water is added to the honey and well mixed and sterilised by boiling. As the liquid cools flavouring is added, and it is then fermented with brewers' yeast.

The general routine of beer-brewing is well known. Brewers' yeast is *Saccharomyces cerevisiæ*. Many strains of this species are known; they are generally classified as top or high yeasts, and bottom or low yeasts. Brewery yeast must generate certain substances possessing a characteristic aromatic taste or odour. It must also readily separate from the fluid, leaving a clear, bright liquid. This species has been studied more thoroughly than any other fungus. Many breweries have long had their

<sup>10</sup> Not to be confused with *Mycoderma aceti* = *Acetobacter aceti*, the vinegar plant.

own special yeasts for inoculating the wort. These give the slightly different, well-known characteristics associated with the names immortalised by Calverley: 'O Beer, O Hodgson, Guinness, Allsopp, Bass! Names that should be on every infant's tongue!' Pure cultures of bottom yeasts used for light beers are maintained fairly easily in an uncontaminated condition. Top yeasts are more liable to be mixed with foreign or wild yeasts, which are deleterious and give rise to 'disease,' though certain non-sporing yeasts are frequently associated with the conditioning of English bottled beers.

K. Kruis and J. Šatava working in Czechoslovakia in 1918 showed that there was an alternation of generations in yeasts and regarded *Torula* and other non-sporing yeasts as haploid forms. Little notice was taken of their work, but recently Ö. Winge, of the famous Carlsberg Laboratories, has independently confirmed some of their results. The difference in haplophase and diplophase is remarkable in some fungi, as for example in *Ustilago laevis* and *U. Hordei*, where the unfused conidium is unable to infect the host plant. We may anticipate some similarly distinct physiological differences among the yeasts.

The art of distillation for the preparation of beverages apparently dates back as far as 2000 B.C., and St. Patrick is reputed to have taught it to the Irish. Whisky and gin are prepared from barley in a manner similar to beer. The malt, however, is left until the whole of the dextrin is converted into maltose, so that in subsequent fermentation by yeast the maximum amount of alcohol is produced. The strains of yeast employed have a high fermentative power.

To turn for a moment to the fuel problem which is becoming of increasing significance. It has been estimated that English coal will be exhausted in four hundred years, and that of the United States in four thousand years if there is no increase in its consumption; whereas if the rapid increase of the recent past is continued these periods will be reduced to fifty and five hundred years respectively. Although petroleum is an obvious substitute, the supply of this is doomed to suffer through modern excessive use. Consequently other fuel sources have been suggested, but the future doubtless lies with power alcohol to be obtained from plant materials, either cellulose, sugar or starch. Alcohol is one of the most important chemicals, and its cheap production is absolutely essential for the development of many new industries. In the preparation of industrial alcohol, sugar-beet, beet- or cane-molasses, potato, maize, rice or similar starchy materials are used. The old process resembles that for the production of potable spirit, but the ingredients are inferior. The propagation and culture of the yeast is the most important step in the process. The aim is to have sufficient active pure yeast so that the fermentation can proceed rapidly; distillation is carried out so soon as the fermentation is complete, and this prevents the loss of alcohol—the yeasts tend to overgrow all other organisms so long as sugar is present. The carbon dioxide obtained as a by-product is now employed to prepare 'Dry Ice' for refrigeration processes.

The method of converting starch into sugar in the malting operations, however, is not entirely satisfactory, and recourse has been had to



the properties of micro-organisms for bringing this about. The best known of these methods is the Amylo process which was introduced about forty years ago, and is utilised either in its original form, or in some modification, in almost every country in the world where the fermentation of starchy material is carried on. Several moulds have the power of converting starch into sugar, but the species first patented by Calmette and Boidin was *Mucor* (*Amylomyces*) *Rouxii*,<sup>11</sup> which Calmette had found in 'Chinese rice,' used in various oriental fermentations. Sterilised corn-mash in a closed vessel is inoculated with a very small quantity of fungus and filtered air is blown through the fluid for several hours. The mould develops very rapidly and converts the starch. Pure-yeast cultures are added and develop in the ordinary way; the species employed is *Saccharomyces anamensis* from sugar-cane in Cochin China. Although the *Mucor* itself is able to ferment the sugar, yeast acts more rapidly and gives a greater percentage of alcohol. The process has been modified with the years and other species have since been used in place of *Mucor Rouxii*, first *Amylomyces*  $\beta$  (*Rhizopus japonicus*) and *Amylomyces*  $\gamma$  (*R. tonkinensis*), and now *Rhizopus Delemar*.<sup>12</sup> A similar process is that of Boulard in which *Mucor Boulard* No. 5 is employed, a species obtained originally from grains in the Far East. This fungus is characterised by its saccharifying power, and its ability to hold its own against infection; consequently the process is carried out in open vats much as in ordinary grain distilleries. Mould and yeast are added at the same time, the special yeasts employed being the rapidly acting Yeast Boulard Nos. 21-30. Neither the Amylo nor the Boulard process has been adopted in countries like England where the excise laws require that the gravity of distillers' wort shall be determined before fermentation by the saccharimeter, which is not possible where the two stages are simultaneous. Owing to the adaptability of these processes to high temperatures they are suitable for tropical and subtropical countries.

Almost every nation has its ancient fermented drink. Kvass, the commonest beverage in Russia, is usually prepared by mixing barley-malt, rye-malt, and rye-flour in equal parts, stirring with boiling water, allowing to stand for some hours, diluting with more boiling water, then adding yeast. After incubating for two or three days peppermint is added for flavouring. Kvass is served out as a ration to the Russian troops. Similar beverages are prepared in Hungary, Yugoslavia and Roumania, millet or maize being used and honey or sugar added.

Pulque, the national beverage of Mexico, is prepared by fermenting the juice obtained by tapping *Agave*, species of which are grown for the purpose; several millions of capital are sunk in the business. Some of the juice is allowed to ferment naturally for about ten days and a small amount of this is added to fresh juice. Fermentation proceeds rapidly, and the drink is ready after a day or two. A couple of yeasts (No. 1 and No. 2) have been recorded as responsible for the fermentation. Alcoholic

<sup>11</sup> The specific epithet is often wrongly written *Rouxianus*. The fungus has also been isolated from soil from North Greenland.

<sup>12</sup> Several species of *Rhizopus* have been described from Japanese and Chinese foods.



fermentation has been regarded until recently as the perquisite of fungi, but Lindner has isolated a bacterium from pulque, *Termobacterium mobile*, which provokes a reaction very closely resembling pure alcoholic fermentation. Pulque is very like sour milk in flavour, and is much esteemed for its cooling properties, though the natives also regard it as nutritious.

Other fermented liquors which appear to owe their main characteristics to yeasts are Taette, a thick viscous non-coagulated milk product with an agreeable acid taste, known in Scandinavia from antiquity; Biti, a wine of West Africa prepared from the tubercles of *Osbeckia grandiflora*; Sorgho, an alcoholic drink of Manchuria, made from *Sorghun saccharatum*, and Nigger beer of East Africa from millet.

Probably few of the drinks prepared in a more or less casual manner so far as concerns the essentials of the process—though special rites may attend their preparation—owe their alcoholic properties entirely to one organism. Sometimes allied species take part in the general mass-action in a manner similar to that in which wild yeasts sometimes enter into the fermentation of beer-wort; often doubtless some of these foreign organisms interfere with the normal process.

Apart, however, from these casual associations which may work in harmony or antagonistically, there are several fermented drinks, some very ancient, which owe their properties to the regular association of two or more organisms.

One of the best known of these is the old English Ginger Beer ousted to a great extent by the manufacturer, who either allows natural fermentation to take place, or adds brewers' yeast: the so-called ginger beer of the aerated water type is entirely different. The 'ginger-beer plant,' however, becomes widely known at times. Immediately after the War it was to be obtained all over the country as Californian Bees, American Bees—and as the generally accepted belief was that it had been brought home by soldiers on active service—Macedonian Bees, Jerusalem Bees, and so on. Professor T. G. B. Osborn tells me that it is often sold by pedlars in Australia. The plant is a globular white mass usually about the size of a pea, and is used for fermenting a sugary fluid. The production of carbon dioxide causes the mass to rise to the surface of the liquid, and it settles down again after the liberation of the gas. There is thus a constant slow up-and-down movement which during the last epidemic was the cause of considerable interference with what Peacock calls 'the honeyed ease of the Civil Servant's working day'—at least for one. The constituents of the mass are a yeast (*Saccharomyces pyriformis*) and a bacterium (*Bacterium vermiforme*); the bacterium has a pellucid, swollen, glutinous sheath, and the yeast cells appear to be mechanically entangled in the matrix of coiled filaments. Other organisms are frequently present but are not regarded as essential. The yeast works more efficiently in the presence of the bacterium which, moreover, apparently also aids by preventing the products of fermentation from reaching the yeast, possibly by destroying some of them; the products are different from those when each organism acts alone—large quantities of carbon dioxide, lactic acid, and little or no alcohol. It is not unlikely that the ginger-beer plant arose as a contamination of raw

sugar, for a similar if not identical 'organism' has been found in Jamaica.

Mexican Tibi also owes its production to the association of a yeast (*Pichia Radaisii*) and a bacterium (*Bacterium mexicanum*), which occur naturally on the prickly pear (*Opuntia*) in rounded transparent masses similar to the ginger-beer plant. These placed in a syrupy solution produce a sparkling, slightly acid drink very popular with the working classes.<sup>13</sup> The yeast is unable to act in the presence of air; the bacterium plays the part of keeping down the amount of oxygen. The natural occurrence of the 'organism' recalls the fact that the sugary exudations from trees, known as slime-flux, constantly harbour a mass of bacteria, yeasts, and interesting yeast-like fungi, several of which are known only from this habitat.

Another combined yeast-bacterium mass which has been distributed widely over northern Europe as a cure for such ailments as consumption is grown in sweetened tea, and forms a heavy gelatinous scum on the surface. G. Lindau, who obtained it from Curland, described it as a new genus of yeasts, *Medusomyces* (*M. Gisevii*). P. Lindner, however, showed that it is a mixture of organisms, but mainly a yeast (*Saccharomycodes Ludwigii*) and a bacterium (*Bacterium xylinum*).

Recently what is essentially the same beverage has received considerable notice in the eastern tropics as Tea Cider. Ordinary tea has ten per cent. sugar added to it and is then inoculated with the 'mould' *Saccharomycodes Ludwigii*—*Bacterium xylinum*. The time for the completion of the fermentation is from two days upwards depending upon the altitude and temperature. The beverage contains up to three per cent. alcohol and is slightly acid, with an agreeable aromatic flavour. There has been a good deal of propaganda in Java which has led to its increased popularity. Its reputed medicinal qualities have also brought about an extensive use in Javan villages. The attempt to popularise it in Ceylon has not been viewed with favour by the excise authorities. C. H. Gadd says that the bacterium is the essential constituent, for this gives the characteristic flavour and odour, and that yeasts other than *Saccharomycodes Ludwigii* will work in conjunction with it.

As indicating how such organisms may have first entered into use I may mention that I have isolated a similar gelatinous mass from the dregs accidentally left in a teacup for a month or so.

The fermentation of milk is deliberately arranged in many parts of the world with resultant beverages which go far back in the history of the peoples; milk-wine according to Herodotus was known to the Scythians. One of these is Kephir, the effervescent, alcoholic sour milk of western Asia. The kephir grains which are employed in the production of the drink are white or yellowish irregularly shaped masses, about the size of a walnut, tough and cartilaginous when fresh and brittle when dry. The tradition is that they were a divine gift to Mohammed; they are regularly sold in druggists' shops. H. von Freudenreich isolated a yeast

<sup>13</sup> Pabst states that Tiby or 'grains vivantes' was used in Paris about 1890 to ferment weak sugar solutions. The name suggests a further similarity to the ginger-beer plant.



(*Saccharomyces* sp.), two species of *Streptococcus* and a *Bacillus*. The yeast is without the enzyme lactase necessary for fermenting milk-sugar. This is hydrolised by one of the *Streptococci*, the other coagulates the milk; the part played by the *Bacillus* is not known. In other kephir grains, however, yeasts (*Saccharomyces fragilis* and *Torula Kephir*) have been found which possess lactase and so any 'symbiosis' here must be of a different character.

Koumiss is another fermented-milk beverage and is one of the staple articles of diet of Siberian and Caucasian tribes. Mares', asses' or camels' milk is used, and there are the customary slight differences in methods of preparation. A little koumiss from a previous brew is mixed with fresh milk in small casks or vats fitted with a stirring apparatus, or in leathern bottles when the tribe is nomadic. As fermentation nears completion the liquid is transferred to strong bottles which are corked and wired; the continuance of fermentation produces an effervescent drink. The organisms responsible for the fermentation include a yeast (*Saccharomyces* sp.), a lactic acid bacterium and a bacterium which, in the presence of the other two, coagulates the mass so finely that it remains as a viscous fluid. Koumiss has lately been made on a commercial scale because of its reputed medicinal properties.

Egyptian Leben is a similar drink. The milk may be that of the buffalo, the cow or the goat. Here the process is begun by using dried milk from a previous brew to add to the boiled milk. Five organisms are said to play their part in the fermentation, two yeasts (*Saccharomyces lebenis* and *Mycoderma lebenis*) and three bacteria. The yeasts are unable to ferment lactose, which is hydrolised by one of the bacteria.

Mazu is a similar fermented drink of the Armenians, used both as a beverage and for butter-making.

When we turn to the Orient we find that yeasts rarely act alone in bringing about the fermentation resulting in food and drink. The preliminary stages are most frequently associated with the activities of *Mucorineæ* or species of *Aspergillus*.

Arrack is a generic name applied to a number of spirituous liquors. In Java it is prepared from rice-starch by the action of raggi. Raggi is produced by crushing together sugar-cane and galanga root-stock, making this into a paste with rice-meal, then drying and mixing with water and lemon-juice and leaving for two or three days. The liquid is poured off and the pulpy residue is made into flat round cakes. These are inoculated by kneading into them some fresh rice-straw, or by placing them in rice-straw. The cakes, which are articles of commerce in Java, contain many organisms, among which are *Rhizopus Oryzæ* which secretes rennet and diastase, *Monilia javanensis* which ferments sugars, and *Saccharomyces Vordermannii* which appears to be the principal agent in the production of alcohol. Fruit juices, palm juices and rice are fermented to produce arrack.

In Ceylon arrack is distilled chiefly from palm-toddy, which is the fermented juice from unexpanded flower-spathes of coco-nut, date- or palmyra-palms; a century ago whole forests were set apart for the production of toddy. Before fermentation, toddy forms the raw material for the manu-



facture of 'jaggery' or crude sugar. Toddy serves extensively as yeast and no other is employed by Cingalese bakers.

On the Indian continent, arrack is produced from palm-toddy, rice, and the refuse of sugar refineries, but mainly from the flowers of *Bassia*, which are rich in sugars.

The various processes are carried out in so concentrated a liquid that complete fermentation rarely takes place. The 'ferments' are very impure and a high proportion of deleterious by-products occur which probably is responsible for many of the native 'drug' symptoms.

Chinese Rice, Migen or Men, is a 'starter' similar to the Javanese raggi. It appears in commerce as flattened cakes about the size of half-a-crown. The recipe for its production includes over forty ingredients, but no mention is made of the essential fungus included in its manufacture. This is *Mucor Rouxii* which occurs on rice grains. Chinese Rice is prepared from rice rich in starch, which after being husked and bleached is steamed until soft and then cooled on rice-straw mats, sometimes coated with paddy. Spores of the fungus gain entrance from the rice-straw or husks, and they are distributed evenly during stirring. The mats are placed in underground chambers for a couple of days, by which time the fungus is well developed. The grains are next worked up by hand, and exposed in the warmest parts of the cellar. The process is repeated twice before the Chinese Rice is ready. It is used in the preparation of rice spirit.

Japanese Koji differs from Chinese Rice in the fungus concerned being a species of *Aspergillus*. Various kojis are known by the name of the fermentation process for which they are to be used. Shoyu koji is the 'starter' for the soy fermentation. Soy beans (*Glycine* spp.) are highly nutritious, being rich in protein and oil though deficient in starch, and are a staple food in Japan and China, having been cultivated for more than five thousand years. The beans are soaked in cold running water and then cooked until they are soft and cooled and drained as rapidly as possible. The beans are commonly mixed with roasted and powdered wheat to which the spores of *Aspergillus Oryzæ*, *A. flavus* or some closely allied species rich in proteolytic enzymes are added, and the mass is incubated for two or three days until each bean is covered with the fungus. The preparation of koji has passed from the old empiricism to a scientifically controlled process.

Shoyu koji is employed in the preparation of soy sauce, a dark brown, salty liquid made by the fermentation of soy beans with, as a rule, some additional starchy component. The sauce is widely used as seasoning throughout Japan, China and Java, and is the basis of most European and American sauces, giving the characteristic flavour of the Worcestershire type. Though it is rare to see any reference in modern English literature to what J. Ovington in 1696 called 'Souy the choicest of all Sawces,' it was otherwise formerly when Byron wrote 'From travellers accusom'd from a boy To eat their salmon, at the least, with soy,' and cruets always had their soy bottle. Soy beans, having been cooked and mixed with prepared wheat, are inoculated with the koji and emptied into a strong brine, thus producing a mash. Constant daily attention is given to aera-

tion and even distribution of the solid ingredients by stirring. Progressive digestive changes take place over a period of from six months to several years, changes which are partly due to bacteria and yeasts, but mainly to the enzymes of the mould. The rather thick, dark brown mash is siphoned or pressed to produce soy sauce which is boiled, filtered and, in most modern manufactories, processed or Pasteurised.

Tamari is another sauce made either entirely from soy beans alone or with rice as a starchy component. The fermentation, where carried on empirically, is said to be due to *Aspergillus Tamari*.

Miso is the general name for another series of soy-bean products resulting from fermenting cooked soy beans with an *Aspergillus koji*. It is one of the commonest breakfast foods for children.

There is a wide range of oriental foods produced by fermentation with *Aspergillus*. Chinese curd, To-fu, is made from soy-bean milk fermented with mould and ripened in brine. The curd is cut into squares which soon become covered with fungus. They are then placed in brine for further ripening. The curd is canned as white or red squares in a salty liquid.

The national Japanese beverage is Saké, with a history going back more than two thousand years. The starch of hulled and steamed rice is converted into sugar with selected strains of *Aspergillus Oryzæ* of high diastatic power known under various commercial names: the fungus was not isolated until 1878. The sugar produced is then fermented by adding yeasts (*Saccharomyces Sake*, *S. tokyo*, *S. Yeddo*, etc.). A claret-yellow liquid results which is of the same general type as whisky with about fourteen per cent. alcohol. The sugar resulting from the saccharification with *A. Oryzæ* is also concentrated for use as a syrup, Mizaume.

The importance of the four large industries in Japan in which *Aspergillus Oryzæ* is employed may be gathered from the following figures which give the approximate total yearly quantities: Saké (rice wine), 812,000 kilolitres; Shoyu (soy sauce), 902,000 kilolitres; Miso (soy cheese), 1,690,000 kilograms; Shocho (distilled alcoholic liquor), 39,700 kilolitres. The annual money value of all the fermentation industries is approximately £40,000,000.

Yam brandy is prepared similarly by the malting of the starch of yam tubers with *Aspergillus Batatae* and fermenting this with yeast.

Chinese Red Rice, Angkhak, is of peculiar interest. Its origin was long kept secret, but it is now known to be due to the fungus *Monascus purpureus*. Damp rice is spread out in caves and infected with old angkhak. After a few days the rice is coloured an intense purplish red by the luxuriant growth of *Monascus*. The rice is dried and crushed and prepared with a volatile oil. It is exported to other countries, and is employed for colouring all kinds of food-stuffs in a way which recalls the use made of cochineal insects. *Monascus purpureus* occurs naturally on rice grains, and it occasionally causes alarm when seen on rice imported into this country. It is frequent in silo tanks in America: I have seen it also on tallow.

Perhaps it would surprise the music hall comedian to learn that moulds are definitely associated with the ripening of some kinds of cheeses apart



from those obviously showing infection with the attendant faint, sweet smell of green things growing. The art of making cheese goes back to the beginnings of man's pastoral life. It has been held that there is evidence for its preparation in the Swiss lake-villages. Cheese from goats' milk is mentioned in the Iliad, and from the Odyssey it is seen to have played a not inconsiderable part in giving sustenance : the cavern of the Cyclopes had its cheese-dairy. What is said of the preparation shows that there has been little difference since Homeric times. From the fifth century B.C. Sicilian cheeses were sold everywhere. J. Ivolas has suggested that the cheeses of Mt. Lesura which Pliny says were brought from Nîmes to Rome were Roquefort cheese.

Moulds of the genus *Penicillium* play a large part in the ripening of the Camembert-Brie, and the Roquefort-Gorgonzola-Stilton series of cheeses. Milk is first coagulated with rennet or dried calf-stomach linings ; the curd is then separated from the whey, drained and pressed to reduce it to its proper proportions. Subsequent salting modifies the flavour and aids desiccation, but also controls the kind of organism which develops. The various processes are mainly due to enzymes and to bacteria, but the taste of certain cheeses depends largely on the species of *Penicillium* which develops during ripening. It has always been realised that the district where such cheeses are made has a considerable influence on the finished product ; the local customs of ripening cheeses in special caves used from time immemorial has its reason in the fact that the caves are infected with some particular *Penicillium*. Thus O. Laxa has recently shown that Nalzory cheese owes its distinctive characters to *Penicillium nalgiovensis*, which is abundantly present in the caves where the cheese is matured, but has not been found elsewhere in the locality ; he believes that the fungus was introduced in 1885 together with the cheese-manufacturing industry. Last year *The Times* opened its columns to an eulogy of Stilton. The sale of Quenby Hall was recalled in an article entitled 'The Secret of Stilton'—'The . . . etc. etc. about the "secret" of Cheesemaking must be taken to include the specific germ of the Stilton cheese. The brushing probably helps to impart that, but the woodwork of the dairy must also play its part. I have heard of a farmer who was so pleased with the results of his cheesemaking that he decided to have the dairy rebuilt on a larger scale, with all sorts of tiling and slate shelves. Thereafter his cheeses lacked their old esteemed special quality, the reason being that the virtue had departed with the germs in the wooden shelves.' <sup>14</sup>

In making such cheeses as Stilton, Roquefort and Gorgonzola, the curd is so managed as to leave cracks between the particles as they are pressed together. These cheeses show marbling of green mould on cut surfaces. C. Thom and J. N. Currie found that *Penicillium roqueforti* alone of twenty-one species of *Penicillium* was able to tolerate the low oxygen-content which they demonstrated in the air spaces. Thom regards the *Penicillium* in these cheeses as belonging to the same series though other workers have regarded them as distinct species. In the ripening of the thin cakes of the Camembert type of cheese, the fungus *Penicillium*

<sup>14</sup> Cf. Enlever trop souvent les poussières de l'étable et de la laiterie, c'est enlever la crème de sur la lait.—*French proverb*.



*camemberti* covers the entire surface with a floccose, white mycelium, which gradually causes the cheese to take on a soft, smooth texture.

Various strains of *Penicillium roqueforti* and *P. camemberti* have been isolated and in modern scientific cheese-making deliberate infection is now practised. For our series of blue-veined cheeses, D. W. Steuart, and N. S. Golding have recommended consistent inoculation by selected strains of the particular fungus owing to the liability of infection by undesirable species in English cheese factories. It is because of these methods that one sees advertisements such as 'un Roquefort d'origine fabriqué avec du lait de brebis et affiné dans les célèbres caves naturelles de Roquefort.' The French government passed a decree a few years ago that only cheese ripened in this way was entitled to be called Roquefort.

Every organic substance is liable sooner or later to become infected with some kind of mould. Even in Old Testament times we learn that the Gibeonites, working wilily in order to persuade Joshua that they had come from a far country, took care that all the bread of their provision was dry and mouldy; and this, though mentioned last in the list of arrangements, was the first mentioned 'as proof of their story. In the Lambeth manuscripts (1460-1470) we find 'Thou lettest poore men go bare, thy drynkis soweren, thou mouldedest metis where-with the febull myght wele fare.' Robert Hooke in his *Micrographia* has an Observation 'Of blue Mould, and of the first Principles of Vegetation arising from Putrefaction.' He writes: 'The Blue and White and several kinds of hairy mouldy spots, which are observable upon divers kinds of *putrify'd* bodies, whether Animal substances, or Vegetable, such as the skin, raw or dress'd, flesh, bloud, humours, milk, green Cheese, etc. or rotten sappy Wood, or Herbs, Leaves, Barks, Roots, etc. of Plants, are all of them nothing else but several kinds of small and variously figur'd Mushrooms, which, from convenient materials in those *putrifying* bodies, are, by the concurrent heat of the Air, excited to a certain kind of vegetation, which will not be unworthy our more serious speculation and examination . . .' Malpighi (1686) also turned his attention to the microscopical observation of moulds growing on cheese, *Cucurbita*, lemons, oranges, wood, and bread.

As we have seen, man has taken advantage of the natural infection of the juices of fruits, cereals, and so on, and after arranging for such infection to take place as he wished, has come to the stage where the infection is controlled and the organism most suited for his particular purpose is used to bring about the desired change. But modern man does not remain satisfied with the methods of his ancestors, or even with those of his immediate predecessors. It is not only that he desires to make two blades of grass grow where one grew before, but he wants them twice as big at half the cost and twice the speed. He had been going to the ant and considering the lilies for many centuries before he realised that moulds and other microscopic fungi were bringing about changes that he was unable to repeat without their aid.

There is difficulty in apportioning credit for the modern application of moulds to industry. The first step was made by Louis Pasteur in his classical studies on tartaric acid when he used a mould to bring about a

specific chemical action. It appears probable that it was this that gave Pasteur his first interest in ferments. 'If I place one of the salts of racemic acid, paratartrate or racemate of ammonia, for instance, in the ordinary conditions of fermentation, the dextro-tartaric acid alone ferments, the other remains in the liquor. I may say, in passing, that this is the best means of preparing lævo-tartaric acid. Why does the dextro-tartaric acid alone become putrefied? Because the ferments of that fermentation feed more easily on the right than on the left molecules.'<sup>15</sup> Pasteur called the mould *Penicillium glaucum*; but it is still necessary to emphasise that this name as generally understood merely denotes a green *Penicillium* and 'greenness has no more significance in predicting biochemical ability of a *Penicillium* than bayness of a horse in judging his speed in a horse race'; it is of no greater significance in taxonomy.

The other necessary step was made also by Pasteur when in 1860 he used a synthetic medium with the ash of yeast as a basis. This was followed by the laborious work of his pupil, J. Raulin, who replaced the yeast-ash with salts necessary for the maximum growth of *Aspergillus niger*.

Another of Pasteur's favourite pupils, P. van Tieghem, studied the formation of gallic acid from tannin (1867). This acid had been discovered in 1786 by C. W. Scheele in decomposing gall-nuts. In the production of gallic acid, gall-nuts, chiefly of Chinese origin, are powdered, mixed with water and left at 20° to 25° C. for eight to ten days until they are mouldy. Most of the tannin (gallotannic acid) is converted into gallic acid. Van Tieghem found that the active agent in the fermentation is *Aspergillus niger*; the high concentration of the tannin apparently prevents the development of other moulds.

Calmette patented a process in 1904 for the production of gallic acid by fermenting clear tannin extract with '*Aspergillus gallomyces*,' the fungus being kept submerged by means of a mechanical agitator and by introducing large quantities of sterile air.

Gallic acid is a mordant and a constituent of inks. At the beginning of the War it was used in the production of gallocyanine with which American sailors' uniforms were dyed.

Many fermentation reactions are not so simple as they appear at first sight. We know the constitution of the original substance and the final products. It seems certain that the intermediate stages are common in these reactions, but what these are is usually a matter of conjecture and discussion. The time-honoured equation proposed by Gay-Lussac for the fermentation of sugar by yeast gives the main facts but takes no note of possible intermediate stages, and, moreover, does not account for the occurrence of glycerol which Pasteur showed, so early as 1858,<sup>16</sup> might occur in amounts up to three per cent. of the fermented sugar. The uses of glycerol (glycerine) are manifold, but the chief one is in the manu-

<sup>15</sup> *The Life of Pasteur*, by R. Vallery-Radot.

<sup>16</sup> 'I find that alcoholic fermentation is constantly accompanied by the production of glycerine; it is a curious fact. For instance, in one litre of wine there are several grammes of that product which had not been suspected.'—Letter to C. Chappuis.



facture of nitro-glycerine, the most important constituent of high explosives. The blockade of the Allies prevented the import into Germany of fats and oils utilised in the preparation of glycerine, and attention was therefore paid to the possibility of its production by fermenting sugar which was available as raw material. Ordinary fermentation of sugar takes place either in neutral or slightly acid solution, but for over sixty years it has been known that it can proceed in the presence of various alkaline salts. The fermentation reaction proceeds instantaneously and it is impossible to gain an insight into the mechanism of the process by isolating an intermediate product. C. Neuberg has given a scheme for alcoholic fermentation which shows methyl-glyoxal as the probable first stage of the process; this is oxidised to pyruvic acid, which is in its turn decarboxylated to acetaldehyde and carbon dioxide. The problem which was tackled was whether the acetaldehyde could be 'trapped' before it had been oxidised or reduced. Theoretically then for every molecule of acetaldehyde fixed a corresponding molecule of glycerol is to be expected. W. Connstein and K. Lüdecke in 1914 began by adding a number of alkaline compounds such as sodium carbonate and sodium acetate. Infection by lactic-acid bacteria, however, occurred to such an extent that not only was a large quantity of sugar consumed but the glycerine was so contaminated that it was difficult to purify. The alkaline salts were next replaced by disodium sulphite, which, when added to the mash even in very considerable quantities, does not interfere with the action of the yeast, and in addition is a valuable antiseptic. This method was patented in 1915. Apparently it was learned in the United States that 'the Germans were producing glycerine in large quantities by a fermentation process, sugar being the material used,' and federal chemists were set to work on a similar investigation. The general theoretical reasoning again proved fruitful, and successful methods were worked out and patented in the United States, England, the former Austria-Hungary, Switzerland and Japan. During the War the monthly German production of glycerine by this method exceeded 1,000,000 kilograms and twenty to twenty-five per cent. of the sugar used was converted into glycerine. In the United States twenty per cent. glycerine was obtained by fermenting molasses and syrups with Californian wine yeasts. The old method of commercial production has now been reverted to more or less generally because of being the more economical.

In recent years the use of commercial diastase (Takadiastase, Kashiwagi-diastase, Digestin, Protozyme, Oryzyme, Polyzyme and other trade names) has spread extensively especially in America; it originated in Japan. The diastase is of fungal origin, being manufactured from *Aspergillus flavus-Oryzæ*, the species of Japanese koji. Cultivation is carried out on bran (wheat-bran in U.S.A., rice-bran in Japan) or some other cheap, bulky, fibrous substance, sterilised, moistened and spread out on trays. Inoculation is made at a suitable temperature and the fungus rapidly extends over the mass. Growth is stopped at the time of maximum enzymic activity, which is soon after spore-formation, the resulting liquid is then pressed through percolators and filtered through infusorial earth or merely strained. For commercial use the extract is preserved by



adding a disinfectant ; for food or medicinal use it is concentrated or precipitated by alcohol. The product is not pure diastase, but a mixture of enzymes—it has even been called an arsenal of enzymes—hence the commercial name Polyzyme.

Takadiastase, a whitish or yellowish powder, is used in medicine where there is a lack of normal digestive activity, especially that of ptyalin. Owing to J. Takamine working in America—he went there in 1891 with the idea, he says, of introducing the use of *Aspergillus Oryzæ*, which plays such an important part in the natural economy of Japan—and taking out his first patent in 1894, his diastase has been largely employed there in industry. In the weaving of fabrics from cotton, jute and similar fibres, it is often necessary to oversize the warp threads to facilitate weaving. This extra size is removed by an enzymic solution. Takadiastase is also employed to separate the silk fibres comprising the thread as spun by the silkworm. It is also used for clarifying the pectin of apple pomace in jam and jelly-making—the turbidity is due to starch and protein—and to clear sorghum syrup. Commercial diastase can replace soap in laundry work and is a partial substitute for yeast in bread-making.

Investigations carried out during the last forty years on the growth of moulds in culture show the possibilities of the utilisation of their action on sugars and other carbohydrates. The work of Pasteur and his pupils was followed up in many countries, but progress was slow.

In 1891 C. Wehmer began a series of researches which altered the whole complexion of the subject. He was the first to recognise oxalic acid as a definite fermentation product of many fungi—*Aspergillus*, *Penicillium*, *Mucor*. By adding calcium carbonate to a medium consisting of sugar and inorganic salts he showed that *Aspergillus niger* would give yields of calcium oxalate up to 120 per cent. of the sugar. The investigation led to no commercial result as oxalic acid can be produced more economically by purely chemical methods.

Wehmer in 1892 showed that citric acid was a product of fermentation. He obtained excellent yields in cultures where sugar was the only source of carbon, with three species of *Citromyces*, a genus which he differentiated from *Penicillium* on rather slight morphological differences, and because of the citric acid fermentation. It has since been recognised that citric acid is one of the commonest products of fermentation by *Penicillium*. He again used calcium carbonate to fix the acid, and patented a method for commercial production, which, however, was apparently not used to any extent partly because of the slowness of the reaction.

*Aspergillus niger*, best regarded as including several closely related species, is one of the commonest moulds and one of the most studied. No mention was made, however, of its ability to form citric acid until 1913, when B. Zahorski patented a method of producing the acid from carbohydrates by growing stock cultures of *A. niger* on increasing concentrations of citric acid. In 1916 J. N. Currie and C. Thom made comparative studies of oxalic acid production in a number of species of *Penicillium* and *Aspergillus*. The occurrence of a distinct lag in oxalic acid in relation to total acidity in some species of *Aspergillus* led Currie to regard citric acid as one of the intermediate products of the fermentation. In

later work (1917) Currie showed that almost any culture of *Aspergillus niger* on a concentrated sugar solution will produce more citric than oxalic acid. He selected a strain of *A. niger* in which the lag between total acidity and oxalic acid production was greatest and by appropriate sugar concentration devised a method of inhibiting oxalic acid formation. The process was patented. Sucrose is used in solution with the addition of the necessary salts. In two to four days there is a continuous felt of mycelium, and formation of citric acid begins. The fermentation is complete in ten days, the solution is drained off and the mycelium pressed. The amount of acid produced is about equal to half by weight of the sugar used. It was recently stated that a certain American firm, in order to supply the colossal amount of calcium citrate required by the American cheese industry alone, is maintaining nine acres of mycelium of *Aspergillus niger* in constant commission.

Citric acid occurs in the juices of many fruits and formerly was obtained commercially wholly from lemon, lime and bergamot by pressing the fruit and concentrating the juice. It is exported either as concentrated juice or as calcium citrate formed by running in chalk and water or calcium carbonate. The chief exporting country in Europe was Italy. An export duty was placed on calcium citrate by the Italian government, and there was a manufacture tariff imposed by some countries: consequently the juice was utilised on the spot for the production of citric acid or the concentrated juice was exported. It is of interest that in 1929 it was stated in America that there would probably be a shortage of citric acid in England because of the tendency to improve the qualities of Sicilian lemons to meet the demand for higher grade fruit for export. It was overlooked that four years previously a British patent had been taken out by A. Fernbach and J. L. Yuill for commercial production by using dark-coloured *Aspergilli*. There are numerous patents for the production of citric acid by means of fungi and the processes are used on a large commercial scale in England, Belgium, America and Japan. It is no longer considered worth while to attempt further use of fruit juice in new areas.

M. Molliard in 1932 demonstrated gluconic acid as a product of fermentation by *Aspergillus niger*, and later worked out the conditions for the formation of oxalic, citric and gluconic acids. In 1924 W. Butkevitch found a strain of *A. niger* which, in the presence of calcium carbonate, yielded gluconic acid almost exclusively. Three years later O. E. May, H. T. Herrick, C. Thom and J. N. Currie made a comparative study of fungi including species of *Aspergillus*, *Penicillium*, *Monilia* and *Mucor*. No species of the last two produced appreciable amounts of gluconic acid, but several species of *Aspergillus* and *Penicillium* did so, the most productive of which were the *Penicillium luteum-purpurogeneum* series, particularly *P. purpurogeneum* var. *rubrisclerotium*. Herrick and May in 1929 patented a process for the production of gluconic acid from sugars and starchy substances by fermentation with *Penicillium citrinum*, *P. divaricatum* and *P. luteum-purpurogeneum*. Following on this several workers showed that there was increased production when the mould growths were submerged. Herrick and May in collaboration with A. J. Moyer and P. A. Wells found that growing *Penicillium chrysogenum*



mycelium submerged under increasing air pressures in commercial glucose solution to which calcium carbonate had been added, yielded from 80 to 87 per cent. gluconic acid based on the sugar originally present, in eight days from the inoculation with spores. They have recently patented the process with the specification that the air contains substantial amounts of oxygen and agitation is effected by blowing it through the cultures. The same patent covers the preparation of koji acid by *Aspergillus flavus*.

Gluconic acid was formerly characterised by objectionable features in its production and by high costs. It is now finding a commercial outlet because calcium gluconate is preferred to calcium lactate as a means of administering calcium to children. It can be injected into tissues without causing necrosis, and its injection into cows suffering from milk fever has given remarkable results; it has unusual effects in increasing the egg shells of hens suffering from calcium deficiency. It has recently been incorporated in tooth pastes.

There are many other acids formed by moulds. Wehmer in 1918 patented a process for the production of fumaric acid. The fungus employed was named *Aspergillus fumaricus*, but no proper diagnosis was given. Thom regards it as being very close to *A. niger*: according to a statement by Wehmer the fungus ten years later had lost its property of forming the acid.

H. Raistrick and his collaborators working in this country have added a great deal to our knowledge of the metabolic products of moulds. From their continued investigations it seems to be becoming increasingly evident that compounds of almost every type known to organic chemistry can be synthesised. They have succeeded in obtaining sixty compounds never previously prepared in an organic chemist's laboratory. It is suggested by P. W. Clutterbuck that 'it is possible that a particular organism builds up its own particular polysaccharide and from it, by a series of reductions, oxidations, condensations and hydrolyses, synthesises from it its own characteristic metabolism products.' An interesting point arising from their investigations is the production of anthraquinone pigments by some species of *Helminthosporium*. It is well known in the technology of dye-stuffs that such  $\alpha$ -hydroxyanthroquinones give rise to excellent dye-stuffs, but are difficult to manufacture economically. Since the yield is good and sugar is cheap the possibility has arisen of employing these organisms for the manufacture of  $\alpha$ -hydroxyanthroquinone. Another point which shows what practical results may be expected from such research is that penicillin, a metabolism product of *Penicillium notatum*, is non-irritant and non-toxic, but has a strong though differential antibacterial power. Further, it was found that several species of *Fusarium* form large quantities of alcohol from glucose and it is suggested that this might be turned to account technically in the production of alcohol from waste vegetable matter.

The romantic discovery of vitamin D led to the finding of ergosterol in yeasts. A vast amount of research has since been carried out, both with yeasts and with moulds to find the most suitable method of production of ergosterol, which when irradiated gives the antirrachitic



vitamin. Most moulds are able to synthesise fats and sterols. It has been found that many moulds give better results than do yeasts, among the best being *Aspergillus Sydowi* and *Paecilomyces Varioti*. In America ergosterol is being produced on a commercial scale by the growth of moulds; in addition to a greater yield than from yeasts, the commercially valuable takadiastase is a by-product.

Many investigators have studied the production of fats and proteins by moulds. G. E. Ward, L. B. Lockwood, O. E. May and H. T. Herrick recently investigated fat production in sixty-one *Aspergilli* and *Penicillia* and found that in ten of them more than 15 per cent. ether-soluble material was formed. One species, *Penicillium javanicum* from rotten tea-roots in Java, gave as much as 41.5 per cent. fat in 40 per cent. glucose.

Since Delbrück's experiments in 1910 it has been known that ordinary yeast can be utilised for food: for animals it is merely dried but for human food it is treated so that it resembles meat extract in appearance, flavour and composition. In Germany a portion of the excess yeast from breweries is used for making yeast extracts traded under various names.

Marmite (known in America as Vegex) is an extract prepared by autolysis from fresh brewers' yeast; the ferments are killed during the manufacturing process. Because of its vitamin B complex Marmite was used as a ration in Mesopotamia and other war areas where beri-beri was prevalent.

At the outbreak of the War the German yeast-drying factories were fully mobilised and produced 20,000 tons of dried yeast annually for food. When the government reduced the production of beer to 60 per cent. of its pre-war amount *Torula utilis*, 'mineral yeast,' was used in considerable quantity to supplement the bread ration. This non-sporing yeast is a poor fermenter and was cultivated in very dilute molasses with superphosphate, magnesium sulphate and ammonium sulphate with free aeration. No alcohol was formed but 100 grams of molasses produced 130 grams of yeast in eight hours.

The Russians also turned their attention to utilising yeast to help to supplement food-stuffs of which the War had brought about an acute shortage. A commission was appointed in 1917, G. A. Nadson and A. G. Konotine being members. Attention had been called by P. Lindner to the possibility of cultivating certain yeasts for the production of fat. The Russians used *Endomyces vernalis*, 'fat yeast,' which was originally found in slime fluxes of birch and hornbeam. Like *Torula utilis*, *Endomyces vernalis* produces no alcohol. It will grow on different sugars and first develops as long branched hyphæ, rich in proteins, but containing scarcely any fat. Later the hyphæ break up into oidia and the fat content increases, reaching fifteen to twenty per cent. of the dry weight in ten to fifteen days. The fat is a yellowish liquid resembling olive oil. Its chief constituent is triolein but free fatty acids are also present.

Chaston Chapman in 1926 found a species of *Oidium* blocking up sewers, which in two days formed a thick film on nutrient solution; this film contained fifty per cent. crude protein and ten per cent. fat and had the odour and flavour of cream cheese. The possibilities attaching to such

a fungus in times of necessity need not be stressed, for ammonium salts can be obtained from the air and carbohydrates from the hydrolysis of wood.

Towards the end of the War, H. Pringsheim and S. Lichtenstein added a non-pathogenic strain of *Aspergillus fumigatus* to straw moistened with a small amount of ammonium salt in solution. The fungus grew well and raised the total protein content of the straw from one to eight per cent. The mouldy straw was dried and used for feeding sheep, cattle and rabbits. Fed experimentally to sheep it was found that forty per cent. of the protein was assimilated.

J. R. Sanborn has recently shown that species of *Oidium* and *Monilia* concerned in the formation of pulp and paper-mill slimes produce doughy and somewhat rubbery growth with great rapidity in media rich in carbohydrates, and has succeeded in producing a satisfactory parchment-like membrane from them. R. O. Herzog and A. Meier took out an American patent in 1915 for making a leather substitute by tanning a similar growth formed by *Bacterium xylinum*, *B. xylinoides* or *Mucor Boidin*.

In the search for acetone to produce cordite during the War, A. Fernbach and E. H. Strange patented a method for its production (together with acetates and pyruvates) with *Mucor Rouxii*. The full story of acetone production in this country with its military, political and financial results is one of the romances of microbiology.

Artificial ageing of green coffee has been attempted by a number of methods, many of which have been patented. F. W. Robison in 1919 patented a method of using moulds (*Aspergillus ochraceus*) for this purpose. 'A green Java or a Brazilian Santos can be transformed in ten days from a characteristic high-grade rough coffee to a smooth, creamy, Java-like coffee.'

From the nuclein of yeast nucleic acid is obtained and combined with silver, calcium or sodium. The compounds thus formed show marked bactericidal action on injection, together with a large increase in leucocytes and are not irritable.

Yeasts have also been used in the manufacture of synthetic plastics, and for assisting the growth of organisms in sewage disposal plants.

To turn to the opposite extreme. The enzyme invertase is prepared on a commercial scale from yeasts. Several processes have been devised to use it for inverting sucrose in the manufacture of various syrups. It is also used in the American candy trade because sweets made from fructose are more tenacious when wet and more retentive of moisture than when made from cane sugar. As a result of increased solubility in the syrup phase the growth of micro-organisms is retarded or prevented and thus the 'explosive' fermentation which causes so much financial loss by bursting and shattering candy is eliminated.

Many of the processes here outlined have been patented. It is not my purpose to comment on this beyond saying that a great deal of mycological and bacteriological information lies hidden in patent specifications. All who have tried to find their way amongst these know how Herculean the task is—I have merely skimmed the surface, as may be judged from

the fact that F. Wagner in his *Presshefe und Gärungsalkohole*, 1914-1935, lists a little over 1,800 patents.

And so I come to the end of my matters. Much of interest has had to be omitted, as for example the relation of entomogenous fungi to insect epidemics, and the utilisation of cellulose material, and it has not been possible to develop any aspect of the subject in the manner of many of my predecessors, who reviewed philosophically tendencies of the past or speculated on future progress. What of the future? Though a fairly large number of fungi have been investigated they form a very small percentage of the total, of which we have yet no idea of the probable limit. The possibilities for practical results are endless, and the processes carried out by these strange organisms are pregnant with probabilities. To some it is of interest to know what an organism is, to others to know what it does and to others how it does it. Here we have a field in which the taxonomist, the chemist and the physiologist can work together profitably in the cause of science—which is the good of humanity.



## SECTION L.—EDUCATIONAL SCIENCE.

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# THE FUTURE IN EDUCATION

ADDRESS BY

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OUR view of the future of education will depend on our view of education itself, but presumably we should all accept the following maxims: 'Every individual has a threefold function in the world—to make a livelihood, to be a citizen and to be a man'; and 'The duty of the state is to see that, so far as education is concerned, everyone has the opportunity of performing these three functions.' They vary in difficulty. It is easier to make a living than to have the intelligence, the knowledge and the disinterestedness which, ideally, every voter requires. But there is something more difficult still. The third function of education is to make men in the sense of Shakespeare's description of us: 'What a piece of work is man! How noble in reason! How infinite in faculty! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals!' The task of education is to take the rough-hewn block which it receives from the quarry of nature and shape from it a human figure, to develop the faculties, and quicken and discipline the reason and apprehension, so that before it leaves the workshop there is at least a chance and a hope that it may become, if not a paragon of animals, at least a piece of work. The model to which education should work in every human being is a figure with a body, a character and a mind, each of which is capable of development towards an ideal: a body with its own perfection of physical development and fitness, of health, of skill of hand and precision of eye; a character, whose excellence lies in the great virtues; a mind, capable of some perception of what the world is, and of what man has done and has been and may be. That is the pattern to which education works, and which she tries to reproduce in a medium sometimes plastic, oftener stubborn. She is limited by her material. No unflawed figure ever comes from her workshop. But she, or rather we, are to blame for any product in which one cannot discern the outline of a man. The final goal of education is not the capacity to earn one's bread or to live in a community, though these are included in it, but the making of human beings. Body, character and, in the widest sense, reason, make the man. A body undeveloped, a character weak or debased, a mind unaware of the universe which we inhabit or

of the achievements and ideals of mankind, proclaim the failure of education and walk the world as a standing reproach to it.

It follows that education, for all men and women, for the artisan and labourer as well as for the 'educated classes,' must find ample room for a liberal, cultural element. If its aim is to make men and citizens as well as bread-winners, to develop what Shakespeare calls beings of infinite capacity, and to help them to live intelligently in the world which they inhabit, then handicraft, technical skill, physical training belong to such an education, if the body is to achieve its perfection, and hand and eye to develop their powers; but so also does science, if we are to understand something of the physical universe; and so do literature, history and, in an untechnical sense, philosophy. Some people may feel that the cultural subjects are unsuitable for the masses. That is a possible view. But to hold it is to accept the most ruthless of class systems, to say that men differ not only in degree but in kind, and that the majority are incapable of studies without which there can be no intelligent idea either of the universe or of the greatness of the human spirit. If a man is incapable of these studies, he is not, in the Shakespearean sense, a man. And if the majority of the electorate is incapable of them, we must either abandon democracy or resign ourselves to be governed by an electorate which can never know what a state should be. Ancient tradition and political instinct may preserve such a democracy from disaster, but not only will its stability be precarious but its political and spiritual life will be poor. The bad film and the betting news will be its relaxation; the bad press its literature; passion, prejudice, the catchword and the slogan, will be its masters.

To this—and it is a danger to society as great as war, if less spectacular—humanistic studies are the great, perhaps the only, antidote. Here are written all the ideals and adventures of mankind. Literature contains the visions which his dreaming mind has conceived in solitude; history exhibits these visions applied to life and tested by fact. Here is seen man in a remote past climbing with stumbling footsteps out of savagery; then, with progress so gradual that we hesitate to give it the name, with endless experiments, aberrations, collapses, false starts, surmounting the obstacles which Nature, his fellow-beings, his own physical and moral limitations put in his path; moving on through the rise and fall of nations, shifts of power, changes of creed and opinion, complete failure or half success, making his way by rare glimpses of light or in thick darkness, and obstinately pursuing a good, dim to discern and difficult to achieve. The lesson of these studies is *Sursum corda*: they are a perpetual rebuke to the feeble vision and failing faith from which all men suffer, and to the selfcontented spiritual mediocrity which is a special danger of democracy; without them men know neither themselves nor their possibilities.

How far does our education make men and citizens? The measure of its success defines our achievement, its shortcomings indicate what remains to be done. It has achieved much. Between the Forster



Education Act of 1870 and the 1891 Act the country organised elementary education. The Balfour Act of 1902 began a new era in the organisation of secondary education. In the early years of the twentieth century universities were created throughout the country. \* Since 1889 technical instruction has been developed thoroughly and effectively. That is a great achievement. In all these fields—university, secondary, technical, elementary—the problem has been faced and roughly solved. Improvements and developments will come ; but the main lines have been well laid and are not likely to be altered. We have the tools, even if we may often use them ineffectively. In the future they may be improved and elaborated,<sup>1</sup> but perhaps the chief improvement necessary is that we should learn more of their use and purpose, and our worst failures are due to the fact that we drift into and through education in a mechanical, automatic, unthinking way, instead of clearly defining to our own minds what we wish education to do for us and asking whether it is doing it and, if not, why not. Like religion, education quickly degenerates into a routine ; then its meaning and its effects are lost. Still the late nineteenth and early twentieth centuries have done a great and solid work in it. So far, so good. But are we an educated nation ?

An English officer in Italy during the war, having to give an instruction course to his men, set as a preliminary test a general paper in which occurred the question : ‘ What do you know of any of the following persons ? ’ The persons in the question are here set out in the order indicating which of them were most familiar to the candidates, and the figures after each name show the number of candidates who identified each person : Charles Peace 19, George Stephenson 16, Von Tirpitz 15, Nat Gould 14, C. B. Fry 11, Sir H. Plumer 9, Woodrow Wilson 8, Clemenceau 7, Michael Angelo 6, Sir R. Borden 6, Milton 4, Havelock Wilson 4, Lord Milner 2, Sir Henry Havelock 1.

There are several striking features in the result. Nineteen men had heard of Charles Peace to two who had heard of Lord Milner. Though the paper was set in the summer of 1918, when names like Wilson and Clemenceau were on everyone’s lips, there is a surprising ignorance of statesmen who played a decisive part in the war. Even the name of their own army commander, Sir Henry Plumer (as he then was), was unfamiliar to his men. Yet, as the unexpected knowledge of Michael Angelo shows, they were quite capable of ‘ high-brow ’ interests. Six, at any rate, of the men had during the months spent in Italy learnt something of a great Italian. But the most interesting point for our purposes is the light thrown on the results of our elementary education. The examinees, men of a war-time regiment, were a fair sample of the average man. They were neither half-witted nor wholly ignorant. But their teachers had been the cheap press, their reading its sporting news and murder reports, their politics learnt from its headlines. The result is not adequate to an expenditure on elementary education of over seventy millions.

<sup>1</sup> Post-primary education, for instance, is likely to become, at least for the many, more practical and less literary.



That examination paper indicates the gap—the bottomless pit, I had almost said—in our national education and the task of the next twenty years. We have left the vast majority of the population without any kind of liberal education.\* We have provided for the minority who attend secondary school and university. We have shown the rest a glimpse of the promised land, and left them outside it. Aristotle may have gone too far when he said that the object of education was to help men to use their leisure rightly. But we have treated the majority as if they were to have no leisure, or as if it did not matter how they used what leisure they had. Art, music, science, literature were for the few. The rest were disinherited from some of the purest and highest pleasures. They might be machines or animals; men in the Shakespearean sense they could not be. That is the type of democracy with which we have been, and are, content.

It mattered, perhaps, the less in the past. When the working-man had no leisure, why educate him to use something that he would never have? The question barely arose. But to-day it is arising, and in the near future it is likely to be urgent. In 1900 most men had enough to do to earn a living. In 1940 or 1950 they will probably have the opportunity to be more than bread-winners. But if the leisure of the future is to be entirely devoted to the films and the dogs, civilisation will not have gained much by it. Fifty years ago the employment of leisure was no problem for any but the well-to-do, who mostly wasted it. To-day it is becoming a commonplace of education.

What, then, would you say of a nation which believed this, and which then acquiesced in the greater part of its people leaving school at the age of 14 and being thrown straight into the deep waters of life. Would not the old proverb rise to your mind, *Parturiunt montes, nascetur ridiculus mus*. In this matter our attitude has been as complacent and unthinking, if not as disastrous and cruel, as that of our ancestors who acquiesced in social iniquities which seem incredible to us. We have accepted it with the equanimity with which they accepted the slave-trade, child-labour and debtor's prisons. For consider what a child has learnt by the age of 14. He can read and write and do arithmetic. He has made a beginning in many subjects, and received a training which enables him to use an opportunity of learning more. But of history, except in a superficial sense, he knows nothing; of the forces that affect the fortunes of the country, which as a voter he will help to determine, he knows nothing; economics, historical traditions, political theories are a closed mystery to him; he will have opened the great book of literature but he has had little time to turn its pages; of science he is even more ignorant. Most of my audience probably did not leave school at 14; many have gone to the University. Let them ask themselves how it would have fared with their intellectual and spiritual life if their education had ceased at 14. Would they be willing that their own children should leave school at that age? Yet that is the lot of the great majority of children in this country. And we have been singularly complacent about it. The task of the future is clear. It is to meet the needs of those who now leave school at 14, 15

or 16, and then say farewell to education for ever. For them we have done practically nothing. The problem has been barely touched and never clearly envisaged. Here, by the side of the impressive architecture of our elementary, secondary and university system, a few scattered buildings rise above the ground, watertight indeed and solid so far as they go, but haphazard, unco-ordinated, and inadequate to the need. The task of the future, I repeat, is to deal with this, our great educational scandal.<sup>2</sup>

Before I make some practical proposals for its removal, I should like to suggest certain principles which we must observe if our efforts are to be successful, and to which little attention has hitherto been paid. They apply to all forms of education except the elementary stage, and some of the weaknesses of our existing system are due to their being overlooked. The first of these principles is that education must be adjusted not only to the natural capacities of the pupil but also to the stage of development which his brain has reached; that certain forms of study are appropriate to certain ages. That is a platitude. What need then to stress a principle which everyone accepts. Yet, if accepted, is it remembered by an age which has acquiesced in the idea that most of the population should leave school at 14, and is now comforted by the thought that in future they may not leave it till a year later? At the ages of 14 or 15 the mind cannot cope with, if it can conceive, the subjects which compose a liberal education and are vital to the citizen. A boy reads literature—*Hamlet* or *King Lear*—and should read them. But what can the profound scepticisms of *Hamlet*, the passion and agony of *Lear* mean to him? He reads history. Can he form a true conception of Charles and Cromwell, Bismarck and Napoleon III? At 18 we may scan the surface of history and literature, but we cannot see below it. Those waters are very deep and only the adult mind can swim in them. Still more does this apply to the political questions on which an elector has to express an opinion. Unless you believe that these subjects are not meant for the masses and that the voter needs no further education for his duty than experience of life, the newspapers, and the speeches of political candidates, you are admitting the absurdity of an education which stops at 14 or 15. The Hadow Report spoke of giving 'a humane or liberal education' through the schools which they proposed. It is one of those phrases sounding, seductive, but untrue, into which all of us are at times betrayed. The

<sup>2</sup> It may be argued that I have exaggerated the position, and said nothing of Junior Technical and Commercial Schools, Junior Evening Institutes, etc., but their nets catch only a small number of the fish. The following figures are instructive:

(a) 476,590 children left P.E. Schools in 1934-35, being 71.9 per cent. of the total number of leavers.

(b) Of these 6,647, i.e. 1.4 per cent., left for further full-time instruction. (The majority of pupils who leave P.E. Schools for full-time instruction leave at an earlier age.)

(c) In the same year there were 75,993 pupils aged 15-16 in Evening Institutes and Evening Courses at Technical and other Colleges.



thing is impossible. It is impossible because 'a humane or liberal education' includes subjects which a fifteen-year-old is not sufficiently adult to grasp.

I have been urging the truism that if we wish to teach a subject, we must teach it at an age when the mind can digest it. Otherwise we shall be like mothers who feed their babies on beans and bacon. But there is another principle, if not more important, even more commonly ignored. The fruitfulness of education, at least in some subjects, depends on experience of life. That is true of the majority of the subjects which are most important to us as men and citizens—literature, philosophy, history and politics. We may study them in books and enjoy them; we shall not appreciate their full significance till we have seen enough of life to have met the things which historians, philosophers and poets are talking about. That is where the so-called humanistic subjects differ profoundly from science and mathematics. Physical science and mathematics need no experience of life to be understood. Their laws are independent of time and place, of human nature,

Based on the crystalline sea  
Of thought and its eternity.

For their comprehension a mind sufficiently clear and powerful to grasp them is required; knowledge of life and of the world is unnecessary. Hence the child mathematical genius; hence Mozart writing a concerto and playing in the Hall of Salzburg University at the age of 5. It is doubtless rare to find the mind sufficiently adult at an early age for such achievements. But, given precocious mental development, the grasp of these abstract relations, whether of number or harmony, presents no difficulties. But such infant prodigies are not found in historical or literary studies. It is necessary to know life itself, to have seen something of human nature, before either achievement or understanding in these fields is possible.

That is the meaning of a famous passage where Newman, with characteristic fineness of perception and beauty of language, points out that full appreciation of literature depends on knowledge of life. 'Let us consider, too, how differently young and old are affected by the words of some classic author, such as Homer or Horace. Passages, which to a boy are but rhetorical commonplaces, neither better nor worse than a hundred others which any clever writer might supply, which he gets by heart and thinks very fine, and imitates, as he thinks, successfully, in his own flowing versification, at length come home to him, when long years have passed, and he has had experience of life, and pierce him, as if he had never before known them, with their sad earnestness and vivid exactness. Then he comes to understand how it is that lines, the birth of some chance morning or evening at an Ionian festival, or among the Sabine hills, have lasted generation after generation, for thousands of years, with a power over the mind, and a charm, which the current literature of his own day, with all its obvious advantages, is utterly unable to rival.'

'When he has had experience of life.' Read Horace and Homer by



all means, says Newman; feed ear and mind with their language and music; but do not expect to know their full meaning before you are 40.

This truth, which Newman expresses in his exquisite prose, was well known to Aristotle. 'One may enquire why a boy, though he may be a mathematician, cannot be a metaphysician or a natural philosopher. Perhaps the answer is that Mathematics deals with abstractions whereas the first principles of Metaphysics and Natural Science are derived from experience: the young can only repeat them without conviction of their truth, whereas the formal concepts of Mathematics are easily understood.' And again, 'the young are not fit to be students of politics, for they have no experience of life and conduct, and it is these that supply the premises and subject-matter of this branch of philosophy.'<sup>3</sup> The countries where students, not content with the theory of politics, take a hand in its practice, have a bitter knowledge of Aristotle's meaning. But it will also be appreciated by those who have watched our own undergraduate students of philosophy playing a game of intellectual ping-pong with the Absolute.

If you doubt the thesis that the humanistic subjects need experience of life for their full appreciation, contrast, in respect of life, of the sense of reality, history as written by those, from Thucydides onwards, who have lived in the political world, and by those who know it only from a study. Again, would not most university teachers agree that their most interesting, I do not say ablest, pupils are those who come to the university not direct from school, but from the army or business or some other occupation where they have seen at first-hand something of the subjects with which literature, philosophy and history deal? Again, which of us has not said in his thirties or forties, 'I wish I could have my education over again'? If you analyse that wish, is it not another way of saying, 'I was not old enough to profit by my education, when I had it'? And if you analyse that statement in turn does it not mean, 'When I was at school and university I did not know enough of life fully either to value my education or to understand what it dealt with'? Perhaps students of science or mathematics would not feel this. If so, it confirms my thesis the more. But I suspect that nine-tenths of those whose studies were humanistic would in later life wish to have their education again, and would agree that in the early twenties they were not mature enough to profit by it.

I am here raising a question which I have no time to discuss, but which needs more discussion than it gets. What *does* a pupil of the age of 14, 15, 16, 17 get from the study of history, for instance? In secondary schools it is a favourite subject for specialisation after the School Certificate. How much of it can a schoolboy grasp? I suspect that the right answer is suggested by the comment of an examiner on the work of a member of an 'Economics Sixth Form' at a public school. 'These boys are excellently taught and interested in the subject; they read and reproduce the best books persuasively; and they have no real understanding of most

<sup>3</sup> *Eth. Nic.* VI. 8. 6. I. 3. 5.

of it, because they do not know at first-hand the subject-matter which it studies.' Δοξόσοφοι ἀντὶ σοφῶν γεγονότες, 'They have the appearance of wisdom but not its reality,' as Plato said of these who absorb information from books without digesting it.

However this may be, if we accept the two principles which I have been stressing and agree that a certain maturity of mind is necessary for humanistic studies and that full understanding of them is impossible without experience of life, some practical conclusions follow. The first is that an education which ends at the age of 14 is not education at all. It might be plausibly argued that nearly all the money spent on elementary education is wasted, because the system is, on the face of it, absurd. If you taught a child the letters of the alphabet and then stopped you would probably consider that you had thrown time away in teaching him the A B C. Yet that is what we do in our elementary education. Elementary education is not complete in itself. It is preparatory. It prepares the pupil to go on to something else, and puts his foot on the first step of the ladder of knowledge. But in fact the vast majority go on to nothing else, they never climb higher on the ladder than the first step. How many pupils whose education ceases when they leave an elementary school maintain afterwards anything that can be called intellectual interest? How many think with any real seriousness about the problems of politics on which as electors they are expected to decide? How many read books worth reading? How many read books at all?<sup>4</sup> And if not, what have they gained adequate to the vast sums spent on them? The chief uses of our present elementary system are to enable a minority to proceed to further education, and the rest to read the *Daily Mail*, *Express* and *Herald*. I am not criticising our elementary schools or their teachers, or denying the necessity of elementary education for all. But unless it leads on to something else, it is as useful as a ladder which has no rungs beyond one or two at its bottom or as a railway from London to Blackpool which ends at Bletchley. To cease education at 14 is as unnatural as to die at 14. The one is physical, the other intellectual, death.

But the defects of our present system will not be remedied by raising the school age to 15, or even to 16. Death at these ages is still premature. The pupil will still be unripe for the studies without which an intelligent democracy cannot be created. I am not arguing against the raising of the school age. It may help our economic difficulties by reducing the supply of children in the labour market. It will keep children longer under influences of discipline and guidance with which they can ill dispense at 14. But the value of the raised school age is moral and economic rather than intellectual. The mind will gain something from it. The character

<sup>4</sup> It is not easy to draw inferences from the statistics of public libraries. The following figures of books issued in a year per head (approximately) of the population by the Urban Libraries of certain counties are characteristic but not encouraging: Cornwall 3, London (Metropolitan Boroughs) 5, Glamorgan 6, Lanarkshire 5. One must, of course, allow for children under 16 and for those who possess adequate libraries of their own, but also remember that many of these books were novels.



will gain more than the mind. Even at 16 intellectual education, in any but a quite elementary sense, is only about to begin. Nobody who has seen the results of compulsory education to the age of 16 in the U.S.A. will be under the delusion that it produces an educated nation. If they compare these results with those obtained in France, where education is compulsory only till the age of 13,<sup>5</sup> they will be still further disillusioned about the intellectual advantages gained by raising the school age. If such a change is preparatory to an education continued into the adult years, well and good; if not, it will leave our problem still unsolved. What is the solution?

It will not be found in secondary education about which this age is, I think, over-credulous. The hard fight for its development has caused us to exaggerate what it can do. We must keep our faith in it, but temper faith with scepticism. Secondary education is only one part of a great picture; we need to stand back a little and see the canvas as a whole. I do not wish to minimise the importance of the secondary school. Economic reasons suggest that the earlier years of life should be given to education. That is the time when the parents are most capable of earning money, and the children least capable of it. Further, it is the best age for learning such subjects as foreign languages, for memorising facts and for tolerating and even enjoying what to an adult is drudgery. But I doubt if any candid person, who has been a teacher or a pupil in a secondary school, feels that the returns correspond to the labour, time and money spent. How should they? You are teaching pupils in whom no intellectual faculty except that of memory and possibly imagination is fully developed, who have not, and cannot have, a full perception of the purposes and value of education, and whose eyes—and their teacher's eyes—are apt to be fixed not on its real business, but on School or Higher Certificates or Matriculation or Scholarships. Some take their educational food with a healthy appetite; others attend conscientiously at meal-times; others are compelled to swallow. But forcible feeding is not education. In every point except the economic one adult education has the advantage over secondary education. It is given to students, who desire it, who have the mental development to receive it, and who have the experience of life necessary to value and interpret it; whereas secondary education is given to pupils whose faculties are not fully developed, and who have not seen enough of life fully to comprehend what education is or what it can do for them. Secondary education will always be necessary for the small class who are capable of high achievement in mathematics, science, historical or literary study. It is so firmly established in our national system that its position is not likely to be weakened. But it would be well if we became less confident that the best thing for any boy who can afford it is to stay at school till 18, and if we realised that the education of the masses can never be achieved through secondary education. Let anyone compare a class in a secondary school or even in a university, where the whole time is devoted to acquiring knowledge, with a Workers' Educational Associa-

<sup>5</sup> Children who obtain the *Certificat d'études primaires élémentaires* can leave a year earlier.



tion class, whose students snatch for study a few hours a week from the strain and fatigue of bread-winning. Which is real education? Which yields the greater return?

What, then, should we do? If we lived in Utopia and could reconstruct education without regard either to its past evolution or its present condition or the needs of the practical world, the ideal plan might be for everyone to leave school at 15, and pass into a system, where a part of the week was allotted to school, part to earning the living in some practical occupation, the proportions of each varying with the intellectual abilities of the pupil and the demands of the subjects which he was studying. Such a contact with the practical world would both sharpen the appreciation of the value and purpose of education, and, especially in the humanistic subjects, make their real meaning far more intelligible. Theory would be illuminated by practice, and practice by theory. At present the two are nearly always divorced. We lead a life of action without thought; or we think in a vacuum, without contact with the realities and problems of the world. Neither form of isolation is satisfactory.

A revolution of this kind could be made in a Platonic—or a Communist—state. It is impossible in our own. The small section of the community which proceeds through the secondary school, and thence, reduced in numbers, to a University degree, will continue to follow that beaten path. Their studies will still suffer from ignorance of life. The only possible improvement for them is that some of them may interpose a layer of practical experience between school and university by going into an office or doing some practical job for a period when they leave school; as is now done sometimes by engineers.

Meanwhile there remains the problem of the greater part of the nation, who in future will leave school at 14 or 15. Unless we establish a compulsory part-time continuation system which will carry them on to 18, the education of the earlier years of the youth of the nation will still be largely wasted. If we can establish such a system, they will remain in contact with those subjects to the rudiments of which their elementary education has introduced them, carrying them on to an age when the mind is growing sufficiently mature to begin to appreciate their value and grasp their meaning. Our next step, therefore, should be to retain those who leave school before the age of 18 under some educational control—not involving whole-time school attendance—to that age. We shall thus escape their abrupt and untimely expulsion from educational influences, and we shall take them to the threshold of adult education, where the solution of our educational problem must be found. So long as the education of the vast mass of the population ends at the age of 14 or 15 or 16, or even of 17 and 18, so long we shall have, as at present, an uneducated electorate.

Much has been talked, and something has been done, in adult education. The *Handbook of Adult Education*, or the second volume of Mr. Yeaxlee's *Spiritual Values in Adult Education*, give an idea of the large number of bodies concerned in it. Its great success in Britain is the Workers'

Educational Association, whose history shows what a clear aim, pursued with faith and wisdom, can create in a region without form and void. In 1935 there were 59,000 students in W.E.A. classes. The figure is remarkable, till we remember that there are forty-three millions in this island, and that the crowd at a Cup Tie Final is twice as large. The W.E.A. is not to blame for that ; nor indeed are the masses. It provided for their intelligentsia, and wisely concentrated on this need, instead of frustrating its own work by pursuing a variety of inconsistent aims. But necessarily it has left untouched the vast mass of the population. 'A liberal estimate gives 500,000 adults at the very most as the total influenced in any direct way by any kind of organised educational activity.'<sup>6</sup> If so, here is a sparsely populated territory, like America before the pioneers crossed the Alleghanies, with territories of unexplored wealth waiting to be cultivated.

It may of course be true that the vast mass are not only untouched but untouchable, destined for ever to be the helots of the nation, exiles by nature from all but the outermost court of education. We should hesitate to adopt so pessimistic a conclusion. But we might feel that it was true if the experience of Denmark had not shown it to be false. I have no time to dwell on the Danish Folk High School. Sufficient to remember that 30 per cent. of the small farmer and working-class population in that country attend, voluntarily and in part at their own expense, these adult schools, where the course lasts for some 5 months, and the education is humanistic in the sense that it is neither technical nor utilitarian. The Danes have been successful with the very classes with whom we have failed—those for whom the W.E.A. does not provide. If they are capable of this, why not we ? If 30 per cent. of their working classes demand a humanistic education, there is plenty to be done here. Their achievement is the measure of our failure and the indication of what can be done. Why have we not done it ?

My concern is to urge the indispensability of adult education, not to produce a programme of it. This would be a fitting work for the Consultative Committee, which has done so much to shape the earlier stages of national education. The first task would be to review what is being already done, in order to harmonise, develop and complete it ; to define clearly what adult education should be ; and to consider in what forms it can be best digested by those for whom it is meant. I make a few suggestions on two of these points.

I believe that the Danes have a better understanding of the technique of the education of the average man. We have taken too narrow and rigid a view of it. Education for the masses has been conceived as an extension of the existing higher education to the working-man. That was excellent for the intelligentsia of the working-class, but for the majority it was too academic, too 'highbrow.' The Extension Movement and the W.E.A. have carried University studies and methods to a wider public. So far, so good. They reached a certain public, and gave it something which it needed and was capable of assimilating. But in so doing they limited

<sup>6</sup> *The Handbook and Directory of Adult Education* (1929), p. 29.



themselves. Invaluable as their subjects and methods were, they pleased not the million; 'twas caviare to the general. But the general, the million, need food no less than the élite; and in giving it their tastes and digestions must be considered. To nourish them we must enlarge our conception of adult education. Music, drama, handicraft, gardening, and many other subjects are a part of it no less than history, politics, science and literature. The festivals, held so successfully in the small towns of Ulster, where crowded audiences come to listen not only to musical competitions but to verse-speaking, show what a large public can be interested by such things; nor is it only in the houses of the educated that the Symphony Concerts of the B.B.C. are listened to with delight. Subjects like these may well take a large place in the adult education of to-morrow. Not that the academic, book, subjects will be absent. But they too may take a rather different form. Studies of the W.E.A. type will continue. But for the ordinary man, history and literature need to be treated differently. They must be brought into connection with his outlook, interests, mind. History as the Bible conceives it or as Herodotus conceived it, rather than as Thucydides or Acton or Ranke or even Macaulay and Gibbon conceived it: history, not as a study of economic laws or high policy, but as concrete moral philosophy, as scenes from the most romantic of all dramas splendidly staged and greatly acted, as a study of human nature at its highest reach and lowest descent. It is difficult for us, disciplined in different methods, to accustom ourselves to such conceptions; and one of the reasons perhaps why so little progress has been made in adult education is that the teachers have mostly been men with honours degrees who brought to their work the methods and outlook of their own education. At any rate, whoever the teachers are, they need to look elsewhere for models than to W.E.A. classes and Extension Lectures. If we are feeling after adult education for the million, we may be helped by studying the Women's Institutes. That is an institution which embraces almost every type of person. You will find in them domestic servants, cottagers', doctors', landowners' wives, farmers' daughters, the village postmistress, the village school-mistress.

For adult education to be successful, the intellectual digestion of the masses must be studied. If scholars sniff disdainfully at such popularisation, they should be asked to remember the dream which St. Peter had at Joppa. I also think that we shall not succeed, unless—again following the Danes—we make our adult education more social. Even in education man remains a social animal. Consider how often education has burned most brightly at a common hearth, where men gathered together in company to warm their hands at its flame: in antiquity, Socrates in the market-place and gymnasium, the great classical schools of the Academy, the Lyceum, the Stoa, the Museum of Alexandria; in the Middle Ages, the Universities, culminating in the residential university, recognised, at least in the Anglo-Saxon world, as their ideal form; in our own day, the Danish Folk High School and its descendants. These examples may teach us something. No doubt the lamp of wisdom can burn in solitary shrines and even in dismal lecture halls. But for the many its right place is in the simple but



pleasant buildings of a Danish High School, with its gardens, its pictures, its music, its corporate life. Few Women's Institutes are so well housed, but there is in them that social, corporate element, which exists in a residential university and which both educates and makes education attractive. Here also this country has the germ of the future in Summer Schools, and in such institutions as Woodbroke, Fircroft, Coleg Harlech and Newbattle. These are pointers to the adult education of to-morrow.

The arguments for adult education are overwhelming; its difficulties will be great. The Danes have had a comparatively easy task. An agricultural people with seasonal work and slack periods have more opportunities for adult education than an industrial country. In Denmark the small holder or farm-worker can escape from his work for a winter. In England a man who leaves his job will probably lose it, and while he holds it finds his time and energies fully occupied. The Danish Folk High School, so successful in the country, has been a comparative failure in Copenhagen. In fact, unless we really believe in adult education, there will be convincing reasons for doing nothing. If we do believe, we shall remember that Continental nations do not hesitate to take two and three years of their citizens' lives for military service, and we shall be capable of a lesser effort in a greater cause.

The future, if we are wise enough to see it, lies with adult education. In this paper I have spoken of its importance to the masses. But it has other, hardly less important, possibilities. At present life is so arranged that most of us do our thinking in youth at an age when we are not best fitted for it, and having left the University think, systematically, no more. What wonder that middle life finds so many men unaware of recent progress in their own field, unapt for new experiments and ideas, deeply embedded in their rut, while progress waits impatiently for their death and the arrival of the next generation! The time, I believe, will come when men will return to the Universities in middle life, to study systematically the newer developments in their own field, to review and revise their own attitudes and habits of thought. That, incidentally, will be very good for the Universities. These *revenants* will bring their practical experience from the world of action to the world of theory and knowledge; and both theorist and practical man will gain by the contact. It is not so Utopian as it sounds. Doctors, in the busiest of all professions, find time for 'refresher courses.' Teachers do the same; and a former Principal Secretary of the Board of Education once said that in his opinion the outlay on these courses gave the best return of any money spent by the Board. The Colonial Office second men from their Service for study at the Universities. There is no reason why the same should not be done for Members of the Home, Indian and Municipal Services—to mention no others. Politicians, too, might take the opportunity for systematic thought about their problems. If they did so, they would be following the advice of Plato, whose statesmen were alternately retired from political life for study, and returned to govern their country in the light of their studies. Plato was the first to see that the work of education was not com-

plete at the age of 18 or 21, but must continue in a systematic, methodical form into late life. (Even after the age of 50 his ruling class were to continue their studies.) This truth, like his doctrine of the essential equality of the sexes for the work of the state, slumbered forgotten for more than 2000 years: or rather, we have slumbered. It is time to awake.

## SECTION M.—AGRICULTURE.

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# SOIL SCIENCE IN THE TWENTIETH CENTURY

ADDRESS BY  
PROF. J. HENDRICK,  
PRESIDENT OF THE SECTION.

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It is now about a quarter of a century since Agriculture was constituted a full Section of this Association, and during that time many distinguished leaders in Agricultural Science have occupied the office which I have the high honour to fill this year, and among them have been several agricultural chemists, the names of some of whom have been closely identified with research into the soil and its fertility, but I do not think that any of them has ever chosen the fundamental subject of the soil for his presidential address. I have ventured to take this as the subject of the remarks I propose to make this morning, and while I cannot claim that it has any special relevance to the place of our meeting, to most of the visitors to which the sea and the sand are of more interest than the soil, I dare to hope that the importance of the subject may render it not unworthy of the consideration of a section whose very name means culture of the soil.

While none of my predecessors has specifically chosen the definite subject of soil knowledge for his Presidential Address, soil science is so fundamental that it was not possible to avoid it in treating of such subjects as the History of Agriculture, Crop Production and its Problems, or Chemistry and Agriculture, the subject of a very recent President. In fact it is not too much to say that hardly any presidential address on Agriculture can avoid touching on soil science at some point.

It is not necessary for me to labour the importance of knowledge of the soil not only to those interested in agricultural science and research but to the whole community. From the earliest times of civilised human history the soil has played a controlling part in the life of the community, it has been prominent in its literature, law and art as well as in the daily occupations of ordinary men. Even at the present day if we look beyond the narrow confines of our own country, where the overwhelming presence of industry and commerce have to some extent blurred our sense of proportion, to the wider world beyond, we find that the soil and its cultivation is still the most important as well as the most fundamental of human occupations and interests. Agriculture is still the 'Fair Queen of Arts, from Heaven itself who came.'

The soil is not an asset which is wasted by use, but wisely used, it increases rather than diminishes in value. Coal and oil and the ores of



metals when used cannot be replaced. They can be exhausted, as has already happened with coal seams, oil-fields and iron ore deposits, but there are soils which have been used for thousands of years, some of them probably since man first passed from the food gathering and hunting stage and began cultivation, yet they are still fertile. Of course by neglect or wasteful treatment, such as has taken place both in ancient and modern times, a soil can be lowered in fertility and value and become what is called exhausted, but this is a very different use of the word 'exhausted' from its application to an oil-field or a coal seam. The exhausted soil can by skilful treatment, or even by being left alone for a time, be brought back to fertility, but the oil or coal once used is irreplaceable.

The soil is the source of most of our food, of our clothing, and, directly or indirectly, of most of our possessions. Its products are the most important materials of commerce and industry. Even with all the increased powers of production of the last century which have released so many from essential work like soil cultivation, and enabled them to live by the production of articles of luxury,—or without doing anything of use or service for the community at all—nevertheless, from a world point of view, soil cultivation remains overwhelmingly the most important of industries, and many of the other important industries depend directly upon its products or are engaged in producing articles for the use of the husbandman. It is as true in Blackpool to-day as it was in the Garden of Eden, that man is 'made of the dust of the ground.' It is necessary in a community like ours, where we are apt, among towns and factories, to lose sight of the soil, that we should be reminded from time to time that man is dependent on the soil, and that all flesh is grass; that land is not merely a playground for the city dweller, it is the fundamental producer, and the tiller of the soil is more necessary to the community than the cinema operator or even than the coal miner.

There has been a great advance during the present century in our knowledge of soils and in our views of their nature and structure. So also our views on manures and on the fertilisation of the soil, and on the whole meaning of fertility, have been widened, while on the manufacturing and commercial side something amounting almost to a revolution has taken place in the fertiliser industry.

The soil, owing to its primary importance, has naturally been a subject of interest and thought since the earliest times—Greek philosophers and Latin poets have formed their theories about it, and written of the art of cultivation. A great mass of lore about it and its cultivation has been built up by many generations of peasants and farmers and some of my predecessors have already dealt with this subject. In particular the first President of the Section, Sir Thomas Middleton, in his address in 1912 dealt with 'Early Associations for Promoting Agriculture and Improving the Improvers.' With his great knowledge of the early history of Agriculture and of early writers on the subject, his address is a mine of information on the building up of agricultural knowledge before the days of the modern scientific period, when definite search after knowledge, and experiment to increase knowledge, began to replace the slow and uncertain processes of gathering knowledge by practical experience, handed down

largely by oral tradition or by theories spun out of men's heads, untested by experiment.

Most of our scientific knowledge of the soil has been built up during the past century. It was only with the development of modern science and especially of chemistry and geology, that such knowledge could advance, and it was about a century ago that our early knowledge of the chemical composition and mineral constitution of the soil was built up. This knowledge has been advancing ever since but with particular rapidity during the present century.

The oldest and most famous station for research in soils and soil fertility is Rothamsted and in its early days, nearly a century ago, before national systems of agricultural education and research were started in other countries, Britain largely through Rothamsted, which was a private institution financed by its owner, John Lawes, and also through the work of Agricultural Societies and private persons, played a not unworthy part in the development of soil science. But during the latter half of the century agricultural research institutions and teaching institutions, in which much research was carried on, founded with State support increased rapidly in other countries both in Europe and America, while Britain was left with Rothamsted alone, a private institution depending on the public spirit and scientific enthusiasm of an individual. Towards the end of the century, consequently, in spite of all that Rothamsted could do, this country was playing a very small part in the development of agricultural science. This can be easily verified by anyone who cares to look up the agricultural literature of the period and note the scientific output of this country compared with, say, France, Germany or America. If I may become reminiscent for a moment, I would say that I belong to that old generation whose scientific training took place in the latter part of last century. It is difficult for a younger, and more fortunate, generation to realise the conditions of those days. There was practically no agricultural research except at Rothamsted, a private institution with a small staff, and there was almost no education in agricultural science, except the limited supply to be obtained at Cirencester in England and Edinburgh University in Scotland. Those of us who wished to learn anything of agricultural science and research were practically bound to go to Germany, and there were no Government Scholarships, or research grants, or agricultural Scholarships of any kind, to assist a poor student to get there.

The beginnings of an improvement came in 1890 when the Government of the day finding itself with a considerable sum of money which had been ear-marked for the compensation of dispossessed publicans, but unable, owing to parliamentary exigencies, to use it for that purpose, threw it over to the local authorities with a recommendation that they should use it for technical, including agricultural, education. In this casual British manner started our system of national agricultural education. This developed rapidly in the first quarter of the present century to the system we now know, and though no specific provision was yet made for research, naturally, it began to grow, till with the foundation of the Development Commission in 1910, definite provision was made for that also. But this is not my subject. I am merely sketching in a background



against which to show the state of soil science at the beginning of the present century. Besides this history of agricultural education and research in the latter years of last century and the early years of this one, was the subject of the presidential address of the late Prof. T. B. Wood, before this section at Birmingham in 1913.

Soil science in this country was in a comparatively stagnant state at the beginning of this century. Britain had done much in the development of the fertiliser industry, though even in this, while other countries were advancing rapidly, we had been falling somewhat into the background during the last quarter of the nineteenth century.

When the revival of agricultural science began after 1890 one of the chief lines of investigation which was undertaken at first—perhaps because it was the easiest and most obvious—consisted of field experiments on the action of fertilisers on crops.

This was natural. The classical work of Rothamsted consisted largely of fertilisation experiments made upon field plots. This had done much to build up the foundations of our knowledge of crop requirements and soil fertility. The numerous experiments carried out with fertilisers all over the country at the end of last century were partly intended as demonstrations of this old knowledge and partly intended to extend it in details. Besides the resources financial and otherwise of the new agricultural teachers left much to be desired. As a rule they had no experimental farms and they had very limited opportunities for laboratory work, but it was possible with their very limited financial resources to make field experiments with the help of farmers and fertiliser manufacturers. Of fundamental research on the soil there was little or none, the resources in time and money, and perhaps also in knowledge, of teachers rapidly recruited to carry out the new agricultural teaching schemes, were not such as to enable them to do much of the more difficult work which requires properly equipped research laboratories and experimental fields.

A comparison of the text-books on Agriculture and Agricultural Chemistry of the beginning of the century with those of the present day will illustrate the great change in our outlook on soil science. There were no British text-books on soil science in 1900. Any text-books on this subject in English were American. The information on the soil in our text-books on Agriculture and Agricultural Chemistry was derived largely from Geology and Mineralogy, or was information about soil composition and analysis and the use of fertilisers, with a little soil knowledge which had filtered through from foreign sources. Our knowledge of what was being done by soil investigators abroad was not extensive, of what was being done in Russia we knew nothing. Even up to the outbreak of the great war we were still comparatively ignorant of the great movements in soil science which were taking place abroad. We looked upon the soil almost entirely from the point of view of its fertility and usefulness as a medium for the growth of plants, and any study of the soil itself apart from its use as a medium for the production of crops, was almost non-existent.

Britain is a comparatively small country falling within ten degrees of latitude, with a climate which is in all parts temperate and humid and with



a rainfall which is well distributed throughout all seasons of the year and which varies from moderate to high. The soils of Britain had not been studied even over the whole limited range of the country, but almost entirely in a small region in the south-east and mainly at Rothamsted and Woburn. These were looked upon as typical soils and all others were supposed to be more or less similar. If that was not definitely stated, it was tacitly assumed. It may be said that till the present century, and even till the second decade of the present century, our view of soils was narrow and insular. All others were expected to conform to 'This blessed plot, this earth, this England,' and it was a most blessed plot of the south-east of England which was the standard. Even in England itself there are soils which differ very considerably in nature and composition from those of the Rothamsted and Woburn districts. I remember my own state of doubt and confusion when, having been brought up in the true faith as it existed in the nineties, I was transferred to the granitic drift soils of Aberdeenshire and could not make them fit in with my preconceived notions, and had to start to revise many of my beliefs, I was therefore more prepared than some of my generation to open my eyes to the new light which has poured in upon us during the past twenty-five years from Russia, Hungary, Holland and Germany, and from America.

We did ourselves no good service from an imperial point of view by taking such a narrow and insular view of soils. While Britain is a small country of limited latitude and climate the British Empire exists in every latitude and every kind of climate. In agricultural science and not least in soil science, great sections of the British Empire, not merely Canada, but Australia and South Africa as well, came to look to the United States rather than to Britain for information and guidance.

Something of the same kind of constriction of vision is noticeable in other countries. All are apt to judge by the conditions which prevail in their own country and to look at others through their own spectacles. This is of course natural. But there are two great countries which, unlike Britain, extend through wide ranges of latitude and climate. These are Russia and the United States. Russian territory extends from Arctic tundra to the subtropical, and embraces every kind of climate from warm humid and cold humid to arid and desert. The same is true of the United States, especially if we include Canada, which, in this respect, is in very close association with the United States whose workers keep in view the soils of the whole North American continent. Here, again, we have a range of latitude from Arctic to subtropical, and of conditions varying from the humid of the Atlantic and Pacific slopes to the arid conditions of much of the interior. Both the humid and the arid climates vary greatly in temperature conditions ranging from the Arctic to the subtropical. In both these vast countries, as in little Britain itself, there are great variations in Geological conditions, and in all three there are soils derived from a great variety of rocks, igneous, metamorphic and sedimentary.

The scientific work of the United States is published in English and is therefore always easily accessible to us. The work of Hilgard and the Californian School, and of Whitney, Schreiner and other soil investigators of the United States Department of Agriculture, became known to us

early in the present century and began to influence seriously our views on soils. The work of Hilgard in particular introduced us to arid and alkaline soils which, though they do not occur in Britain, are well known and of great importance in India, Australia, South Africa and other parts of the Empire, and we began, though only slowly, to take notice and to learn something of what was going on in the United States. Russia, on the other hand, is cut off from us by the barrier of a language which few can read, and the still more remarkable soil work which was going on in Russia and which has now produced such a great change and widening of the views of soil investigators throughout the world, was unknown in this country till after the great war when it began to filter through to us from America, Germany and other countries. Works published in this country before the war make no mention of the great Russian soil scientists such as Dokuchaev, Glinka and Gedroiz. At the present day it would be impossible to write a book of any significance on soils without giving some account of the work of these men and of the great effect it has had in stimulating study and research on soils throughout the world.

I suppose there is no better known agricultural manual in the English language than 'Soil Conditions and Plant Growth,' by our former President, Sir John Russell, the first edition of which was published in 1912. A very valuable feature of this work, which has been continued and improved in all subsequent editions, is the extensive bibliography which it gives. In the first edition there are 323 entries in this bibliography but not one of them refers to any of the leading Russian soil investigators. In the text no reference is made to the Russian system of classifying soils and dividing them into zones according to the climate. There are, it is true, one or two slight references to climate and its effect on the soil and on the interpretation of soil analysis, but these are not developed or given more than a passing notice. The same is true of the new edition published in 1915 and it is not till the fourth edition, 1921, that references to the great Russian workers begin to be made. The references to them are still slight and their system is not described. In the fifth edition the references to the Russian work are somewhat greater but even yet there is no detail, and it is not till the sixth edition, 1932, that the Russians come into their own and that a considerable amount of space is given to them and to a description of their system of climatic classification.

I have mentioned this particular text-book at some length because it is an outstanding English text-book on soils and because it is in great demand and has passed through a number of editions, so that we can trace in it the gradual growth of recognition in this country of the Russian School and its work.

In this country we remained almost completely ignorant of the Russian and of much other foreign work till after 1920. The most important and valuable agency in spreading among soil scientists of the world a knowledge of one another's work, and especially of the work of the Russians, and thus widening the outlook of them all, is the International Society of Soil Science. This Society was founded in Rome in 1924. It grew out of some previous International Conferences which had been held before and after the great war. The first was held in Budapest in 1909 and was



called the International Conference of Agro-Geology. At it Britain, so far as I am aware, was not represented. The Conference was called mainly because of a division of opinion in Central Europe as to whether soils should be mapped and classified on a geological system or on the Russian system, which was already becoming known in countries bordering on Russia. The Russians were represented by Glinka, and his arguments in favour of treating soils as an independent subject of study and of naming, mapping and classifying them entirely in accordance with soil genetics, independently of geology, produced a great impression, as did also his statement of the view that climate was by far the most important factor in producing different types of soil.

It was decided to hold another agro-geological conference in the following year in Stockholm at the same time as, but independently of, the International Congress of Geology. At this conference further discussion took place and a number of different sections, or commissions, was founded. The outbreak of the world war prevented the holding of further international meetings for a time and the next was not held till 1922 when it met at Prague. The fourth and greatest of all was held in Rome in 1924, where this country was represented by a number of leading soil workers. The Rome conference was much more largely attended than its predecessors and there the International Society of Soil Science was formed and it was decided to hold the first International Congress of the new Society in Washington in 1927. The United States Government took an interest in the matter and, through the President of the United States, invitations were issued to foreign governments to send delegates to the Congress. At this great Congress a strong party of Russians, headed by Glinka, was present, and the discussions which took place with them in Washington and their demonstrations of their views on the soils of America during a journey right across the continent from the Atlantic to the Pacific by a southern route and back again by a northern route, including a large section of Canada, did more to open the eyes, and to bring the meaning of the new soil philosophy to the knowledge of the large number of soil workers who were present from many countries, than anything that had gone before. A strong British party was present at this Congress and to many of us it was a new education in soil science, and not the less so because we found that many of the leaders in soil science in America as well as those from several European countries were in distinct sympathy with the Russians on many of the new views which they were advocating. I would not like to make you think that there were no differences of opinion among the Russians themselves. There were. There were also differences of view between them and other leaders in soil science in America and elsewhere. But these international discussions and differences only made the whole congress the more stimulative and thought-provoking, and those of us who were present came away with our minds clarified and knowing much more definitely than before what was this fresh viewpoint in soil science of which we had been reading and hearing more or less garbled accounts for a few years previously.

Out of these international congresses and conferences and the renewed



interest in soil science a number of new scientific journals arose. *The Internationale Mitteilungen für Bodenkunde* was founded as the official journal of the Agro-Geological Conferences, and, after the foundation of the International Society of Soil Science, was continued as the *Proceedings* of the International Society, while as a supplement a new journal, called *Soil Research*, was also started. In America there has been published since 1916 a journal called *Soil Science*. These journals, like the international meetings, did much to make known widely the new movements in soil science.

What are these fresh views which we all sat at the feet of the Russians to learn? First of all I would like to point out that they are not revolutionary, they are not an overturning of old knowledge but an extension and restatement of it from a fresh viewpoint, and with additions. The Russians have been largely cut off from Western Europe and America by linguistic, geographical and political barriers, and, since the latter part of the nineteenth century, have been thinking out the subject for themselves.

They treat the soil as an independent natural object worthy of study for its own sake and not merely as a useful medium in which to grow crops, or as a subsidiary branch of Geology or Chemistry or any other science. The branch of science which deals with soils they treat as an independent branch, which they call Pedology. Many people in this country and in America have now adopted this term and prefer to be pedologists, a word you will not find in the dictionary, rather than soil scientists. My own preference is for a term which is readily understood by ordinary people, for I venture to think that it is very important that science should have, as far as possible, the sympathy and understanding of ordinary non-scientific people who are apt to be repelled by the unnecessary and pedantic use of unknown terms. As that Nestor of Science and master of virile English, Professor H. E. Armstrong, says, with his usual emphasis, in a recent letter to *Nature*: 'The world of scientific workers is clearly prepared to work in harmonious co-operation and even to mix with the public on equal terms; jargon, not language, alone forbids; this must be stamped out; its use is due to conceit and to lack of thought; knowledge has to be made the common property of the world.'

Next, the Russians insist that the soil is the natural product of a number of soil-forming factors of which the most important is climate, and that its nature is not determined by its geological origin. Their great primary classification of soils is into a number of climatic zones. The most notable feature in the whole Russian philosophy of soils is the insistence on the importance of climate as a soil-forming factor. Climate plays the central part in their system of soil classification. This recognition of climate is not entirely a new idea. Hilgard in America, and others, had already shown that climate has a great effect on the nature and composition of soils. On the other hand, in this country we had been accustomed to think of all soils as being somewhat similar to those of our temperate humid climate and though brought into contact with the very different soils of India, Australia, etc., had never critically examined the nature and causes of the differences in the soils produced in these very different climates.

In the old Russian Empire, and the modern union of Soviets, there are soils which have been produced in a great variety of climates in Russian Europe and Asia. The Russian soil workers set themselves to collect these and to examine them critically, and came to the conclusion that soils produced from a geological formation in a cool climate were very different from those produced from the same geological formation in a hot climate, and that those produced in a moist climate were very different from those produced from the same parent materials in an arid climate. They showed indeed that very different soils may be formed from the same rock in different climates and that, on the other hand, similar soils may be produced from different rocks in similar climates. That, for example, our granitic soils, produced in the cool humid climate of Scotland, would have been very different if produced in a hot humid climate in tropical Africa, and that if produced in a hot arid climate in Asia they would have been different both from those produced in cool humid Scotland and in a hot humid African climate. In fact they showed that soils cannot be classified and characterised on a geological basis. Possibly some of them, and still more some of their enthusiastic converts in other lands, go too far in excluding geological origin altogether as a factor in soil formation.

The next great feature of the Russian system is the classification of soils according to what is found in the soil profile. The profile, as is now well known to all of us, though that was not so twenty years ago, is a section of the soil from the surface down to the parent material. If such a section is examined it is almost invariably found to consist of a number of different layers, called horizons, which are generally easily distinguishable from one another. When a great many such profiles are examined from different parts of the world it is found that they fall into a number of definite types characteristic of the different types of soil. The profile is an expression of the results of the different soil-forming factors and therefore characterises the different types of soils as produced by the action of these factors. This is expressed by saying that the profile is the resultant of the pedogenic processes. The modern soil surveyor studies morphology of soil profiles and classifies his soils accordingly.

This is in outline very simple, in practice it is often very difficult and is apt to give rise to differences of opinion, especially when those accustomed to the profiles of one part of the world are introduced to a new region with conditions different from those to which they are accustomed. It will be seen, too, that this scheme of a profile made up of horizons is a development of the old division of the soil into soil and subsoil. But there is an important difference, the terms soil and subsoil were applied to cultivated soils mainly, and the soil was, generally speaking, the layer which had been mixed and influenced by the implements and processes of cultivation, while the subsoil was the layer which was not touched by instruments of cultivation. Such a division is of no use to the modern student of soil morphology and genetics. The processes of cultivation have turned over and mixed the surface layers and have also modified those below the region reached by the plough. The modern soil investigator, therefore, insists that the profile must be studied in undisturbed soil which has existed in its natural condition for a long period of time. To him the



profile is the soil unit which must be studied as a whole, unmodified by artificial operations of man. This of course introduces difficulties in old settled countries of dense population, like our own, where most of the soils which are worth cultivation have been broken up and cultivated at one time or another. In the extensive, lightly populated areas of Russia or North America there are plenty of natural soils, but in applying modern methods of soil study to the soils of much of Western and Southern Europe and other regions of ancient civilisation, modifications have to be introduced to allow for the influence of cultivation which, in many cases, extends over long periods of time.

There is another difficulty which, it seems to me, has not received the consideration it deserves. Soils are divided in this system into mature and immature, called by those who rejoice in using Greek words unknown to the vulgar, Ektodynamomorphic and Endodynamomorphic soils respectively. A *mature* profile is one which has attained its full development, while an *immature* profile has not attained its full development. But when is this full development attained? Certain of the soil-forming processes require a very long period for their full development, others a much shorter period. Some processes require periods of geological time, others can take place in a few years or a few centuries.

The late Mr. George Newlands and myself studied a few years ago the mineralogical composition of certain Scottish soils, and found that our granitic soils, for instance, are largely composed of the minerals of the original granite in an unweathered or only slightly weathered condition. Much of the 'fine sand,' technically particles of approximately 0.2 to 0.02 millimetres in diameter, consists of almost unweathered particles of orthoclase, muscovite and other compound silicates and not merely of quartz. These are found not only in the parent material a few feet below the surface but in the surface layers which have been undergoing chemical processes of weathering as long as the soil has been there.

The parent material of these soils is glacial detritus powdered down by ice and left behind when the ice melted after the last glacial epoch. How long is that ago? I leave that question to be answered by Section C. At any rate it is a long time ago, before human history started in Scotland. But as the pedogenic processes in these soils are not complete in this respect, the profiles, *ex hypothesi*, cannot have attained their full development and therefore are still immature. But many of such soils have profiles which are treated as mature.

Soil organic matter, on the other hand, is subject to rapid change and decay especially in a warm climate. Even in our cool climate humus is rapidly formed under suitable conditions. So far as the organic matter of the soil is concerned it rapidly comes into a condition of equilibrium with the conditions prevailing, and so far as it is concerned the pedogenic process is completed in a comparatively short period of time, though a change in the conditions may throw it out of equilibrium again for a time.

The whole of the processes of soil formation are very complex and require much more study before we can hope to reach, I will not say a final, but a sound system of soil classification. The soil itself is, from every point of view, a very complex and variable material and our present methods



for its study and classification, though a great advance on what went before, are of very recent origin and no doubt further great progress will be made as a result of the intensive studies to which soils are now being subjected in many lands.

In the above sketch I have merely referred to one or two features of the Russian soil philosophy which appear to me to be outstanding and have not ventured to tax your patience with details which can be found in modern text-books. With the new enthusiasm for soil study and research we have a new crop of books on the subject. At the beginning of this century there was hardly a text-book on soils to be found in English, now there are many both by English and American authors, and in the past ten years there have been quite a number in which the modern views of soil formation and classification are given, and more are constantly appearing. Much of the Russian soil science is at present remote from agricultural practice. It is curious that in spite of their theories of Government and of five-year plans for the rapid practical improvement of the condition of the people, the Russians are the champions of pure soil science, of the view that our study of soils should proceed without reference to any use that may be made of such knowledge for the service of agricultural practice, or for the production of wealth from the soil. It is difficult for British and Americans to dissociate soils from their agricultural use and to regard them as a pure subject of scientific research studied solely for the increase of abstract knowledge. Still, it is no doubt the correct method, so long as it is not carried to extremes, and we are greatly indebted to the Russian School for giving us a fresh start and new methods of attack.

The fundamental importance of soil moisture has been known for ages. Without water crops cannot grow, and with excess of moisture we get marsh or swamp and our ordinary crops are drowned out. A proper supply of moisture is more important to crops than all the fertilisers put together. In the modern theory of soil formation and classification the important part played by water is recognised. The two important factors in climate, those which do most to determine what the soil is to be, are the supply of water and the temperature. In considering water supply it is not sufficient to consider the rainfall—the humidity, the distribution of the rainfall and the topography all enter into the picture. A rainfall which is sufficient to wash through the soil and leach away soluble constituents in a cool humid climate, may all be re-evaporated and leave nothing to wash through the soil in a warm climate with a dry atmosphere. Again, if all the rain falls at one season of the year a part of it may seep through the soil and escape as drainage water, while if the same rainfall is distributed throughout the year so much may be re-evaporated that there will be none to escape as drainage.

Considering the importance in soil formation of water which passes through the soil, and of the amount and nature of materials in solution and suspension which are washed away by such water, or removed by it to lower layers of the soil, and the importance to soil fertility of the relations of the soil to water, and of the economic importance of drainage in connection with the loss of nitrogen, lime and other manurial constituents from the soil, it has always been a matter of surprise to me that more use is

not made in soil studies of drain gauges or lysimeters, or instruments of a similar kind.

The first drain gauges, so far as I am aware, were made by Lawes and Gilbert at Rothamsted over sixty years ago. They were designed to study evaporation and percolation in relation to depth of drainage, and were therefore of different depths, 20, 40 and 60 inches respectively. They were also used to study the amount of nitrogen washed away from uncropped and unmanured soil. The blocks of soil enclosed in these drain gauges were never broken up, they were built with as little disturbance as possible into the water-tight structures which enable the drainage to be measured. They consist therefore of real soils which have been formed by a long course of natural soil-forming processes. Similarly the drain gauges which I have had built at Craibstone, near Aberdeen, have been formed by enclosing, without disturbance, in water-tight boxes of Caithness slate, blocks of natural soil which have never been broken up. My drain gauges are intended to study the changes which take place in cultivated soil, and the losses which take place in the drainage water during ordinary processes of cropping and manuring.

Such drain gauges are not easy to construct. I suppose that is why this method has been so little used in the study of soils. It is much easier, and cheaper, to build a water-tight box and fill subsoil and soil into it, than it is to enclose a block of natural soil, weighing several tons, in a water-tight structure. If the easier method is adopted, as has been done to a large extent in America and elsewhere, its limitations must be recognised. The soil, once it is broken up and filled into a lysimeter, is no longer a natural soil and it is difficult to say how long it will take under the influence of the soil-forming processes of the locality to become once more a real soil such as is provided in nature. Had Lawes and Gilbert, for instance, filled the soil into their drain gauges they would have defeated the object they had in view, for such a broken up soil would have allowed water to run through it quite differently from a natural soil for its structure would have been destroyed, while the breaking up and aeration of the soil would have rendered useless their studies of the loss of nitrate, for the nitrification in such an artificial soil would have been quite abnormal.

Artificially filled drain gauges have certain uses. I have used them myself in studying the limits of fixation of manurial substances by the soil, but we must always recognise that they are artificial and that results obtained from them do not necessarily apply, or may only apply with modifications to natural soils. They are in a similar position to pot experiments as compared with field experiments. Pot experiments can be very useful, and this method of experimentation has yielded most valuable results, but we have always to recognise that it has its limitations and that it is very difficult to find a formula which will enable us to apply the results obtained by it with any degree of certainty to field conditions.

The development of our knowledge of soil colloids and base exchange during the present century is second in importance only to the advance which has been made in the science of soil formation, structure and distribution. As you know, the beginnings of our knowledge of this subject can be traced back to the middle of last century when Way



showed that the ammonium of ammonium sulphate, or the potassium of potassium sulphate, was retained by the soil while an equivalent amount of calcium went into solution and could be washed away as sulphate. He also showed that this power resided in the finest mineral part of the soil, the clay, and he regarded the action as an ordinary case of double decomposition between clay and the soluble, neutral salt in solution. Though there was much discussion about these phenomena, which were regarded as of the greatest practical importance because they showed that valuable manurial bases when applied in a soluble form could be absorbed and retained in the soil, and though soil investigators of last century were divided into two camps, one regarding this fixation of bases as a chemical precipitation by double decomposition and the other looking upon it as a physical process of absorption, little further advance was made till the present century. By that time considerable advance had been made in our knowledge of colloid chemistry and we also knew that there were two types of colloid complexes found in soils, one mineral and the other organic. The mineral colloid material, sometimes known as the alumino-silicic complex, is found in the clay fraction of the soil, while the organic colloid, known as the humus complex, is found in the decomposed vegetable matter or humus matter of the soil. The soil and these colloid constituents of the soil were studied by the methods of colloid chemistry late in last century and early in this one by the Dutchman, van Bemmelen, and later by his fellow countryman, Dr. D. J. Hissink, by the late Professor G. Wiegner of Zurich, whose recent death at the height of his powers we all deplore, and by the famous Russian worker, the late K. K. Gedroiz, whose very valuable work in this subject became generally known only after the great war.

We now know that this process of base exchange is a colloid phenomenon, and follows the laws of colloid chemistry. It is not confined, as Way supposed, to the fine mineral matter of the soil but is a property of the organic colloids also. The old controversy as to whether this is a chemical or a physical phenomenon is thus cleared up and both sides are shown to be right or both wrong, according to your taste, for both sides knew nothing of that border-line field of colloid phenomena where Physics and Chemistry blend, and, in the best modern manner, tend to become indistinguishable.

We are now on firmer ground than we were a few years ago as to the nature and properties of soil colloids, both mineral and organic, and the new knowledge has shed fresh light on certain matters of great practical as well as of great scientific importance, which were wrapped in gloom at the beginning of this century. We can now not only estimate with a high degree of accuracy the degree of intensity of soil acidity, or alkalinity, as well as the amount of such acidity or alkalinity, but we have also a sound theoretical picture of the nature of that acidity or alkalinity.

It was a common statement in our text-books till quite recent years that a supply of calcium carbonate was necessary in a healthy soil. It was useless to point out that there are fertile soils in which no recognisable amount of calcium carbonate can be found. It had to be there. We now know that the part which was ascribed to calcium carbonate is played by the exchangeable bases of the soil, and that in our fertile soils the principal



exchangeable base in combination with the soil colloids is lime. Other bases, magnesia, potash and soda, are also present in smaller amount. When a base is required to combine with any acid or to exchange with and fix other bases these are the ones primarily drawn upon, and the exchange with other bases or the combination with acids which takes place is primarily the settling of an equilibrium between these bases and the acids present, the electro-negative clay and humus colloids themselves acting as acids.

I would like to suggest that some of our methods of soil analysis require revision in the light of this new knowledge of exchangeable bases and the constitution of the clay colloids of soil. Our old methods, or certain of them, were based on the view that calcium carbonate was essential to the soil and that it or the 'lime requirement,' which meant calcium carbonate requirement, were among the more important things to determine in a soil analysis. It seems more important nowadays to set up standard methods of determining exchangeable bases and the requirement of the soil for these.

Our knowledge of the chemistry of humus, in spite of the great amount of work which has been done upon it in recent years by workers in many countries, is still in a state of doubt and darkness, but in the last few years we have learned a great deal of the chemical structure of clay. The application of X-ray methods of analysis has shown that much clay material exhibits a definite lattice structure, and that there are several different minerals, showing at least two different types of lattice structure, to be found in clays. Some light has also been thrown by this work on the nature of the base exchange capacity of clay and on the great differences in base exchange capacity which are found in different types of clay substances.

The X-ray method has supplied us with a very valuable new method of attacking the problem of the structure of clay, and taken along with other methods is clearing up many of the gaps in our knowledge of clay. There is a great deal of work still to be done on this subject but it seems we are now well on the road to success. I may point out that a valuable summary of recent research on the structure of clay has been given by our Recorder, Dr. E. M. Crowther, in *The Annual Reports on the Progress of Applied Chemistry* for 1935.

One cannot give so hopeful an account of the progress of our knowledge of humus. We have not yet found any clear method of unravelling the structure of humus and of showing what is the nature of the colloid molecules which build up the main part of this very important soil constituent.

Both the clay colloids and the humus colloids are acid substances which, when uncombined with bases, render the soil acid, and require to be combined with bases before they can be neutralised and produce a neutral soil, while when fully saturated with strong bases they are alkaline in reaction and can produce a soil of alkaline reaction. To the chemists of a generation ago it would no doubt have appeared rather shocking to apply to indefinite substances of large, undetermined and variable molecular structure the name of acids, but the evidence cannot be otherwise explained, and the recent X-ray work is supplying, in the case of clay at any rate, further evidence of a complex molecular structure which justifies the views which have gradually gained acceptance as to the constitution of these

most important substances, on which the nature and properties of the soil depend to such a great extent.

In many other directions fundamental soil science has made in this century, and is making, marked advances. But I have already kept you long enough. There is, however, one other subject on which, if you will bear with me, I would like to offer a remark before I stop. Fertilisers we may class along with the soil for they are substances used to increase the productivity or make up the deficiencies of the soil. From small beginnings a century ago the fertiliser industry has grown to be one of the world's greatest chemical industries. In the early days of the industry this country played a notable part, but in the latter part of last century and the early part of this one, when the whole of our soil science was in a somewhat backward position, our fertiliser industry also fell into the background. We have recently seen a great revival consequent upon this industry again becoming scientific instead of depending merely upon commercial and business ability. For this change and improvement we may, I think, give much of the credit to Imperial Chemical Industries, who are now our greatest fertiliser manufacturers, and who make the manufacture of manures an important section of their business. The older type of fertiliser manufacturers may have employed a few works analysts, but they did not pay for the best scientific brains to help them to introduce new processes and to improve old ones. That has been changed by I.C.I., and we have a new spirit in the fertiliser industry and we are regaining something of the great position we once held in that important branch of chemical manufacture. It is to be hoped that this will continue. If we are not to fall back into the old state of lethargy we must continue with long-range research, as the Germans and Americans are doing, carried out by educated and competent persons. That is the only way if we are to continue to advance and keep in the front.

Physics is not the only branch of science in which revolutionary changes have been made in the twentieth century. Even in soil science we have seen a structure built up which the agricultural chemists of a generation ago would find strange. In the British Isles at the beginning of the century there was almost no soil science, now we are taking our due part in building up and nurturing this branch of knowledge. We have now not only the great station at Rothamsted but also the Macaulay Institute at Aberdeen, which is engaged in the study of soils of different types from those of the south-east of England and is approaching soil study from a somewhat different angle. There are also in our Universities and Agricultural Colleges quite a number of soil investigators of distinction who are dealing with the soils of many other parts of the country.

At the same time I think it is true to say that in Britain the fundamental attitude towards soil study remains the same. It is difficult for us to achieve the complete detachment of the Russians and study soils entirely apart from any practical agricultural applications which our studies may have. Purely scientific study of the soil is being made in this country also, but we always find it difficult not to remember that the good brown earth is primarily of interest to us for crop growth. It is right that it should be so. It is right to keep pure and applied science in the closest touch with



each other. They should not be studied apart, but together as parts of a great whole. Each gains thereby. Nor can we detach soil science completely from those other branches of science like Chemistry, Physics, Geology and Biology, on which it is founded and out of which it grew.

But to what are we heading? Of what use is it all? Are we only increasing sorrow by increasing knowledge? Our increased knowledge should give us increased power to use the soil, and that surely means increased production. We are told there is already over-production and that what is required is restriction of production. We read in our papers of crops being destroyed because they cannot be used, or because it does not pay to harvest them. In the United States, and elsewhere, the growth of fundamental food crops, like wheat, has been restricted. In our own country arable land is decreasing while at the same time the import of food-stuffs is being restricted.

Has everybody in this country, and in every other country, too much, or even enough, food? Do we not at the same time as we are crying out about over-production, hear an equal outcry about malnutrition and under-feeding even in this comparatively prosperous country? The two things do not fit together. They cry out against one another. They cannot both be right. But we all know that there are many people, forming quite a large section of the population, who have not over-abundance, who have not even enough. This, which is true of this country, is, unless we are strangely misinformed, true in a much higher degree of the world at large. This is not a problem of soil science, but a problem for the statesman, the social reformer and the economist. The soil scientist can safely go on and increase our knowledge of soils, and hope, that in the long run, it will increase production and lessen labour. Increased wealth, especially in the essential things produced from the soil, is a blessing not a curse, and if it can be obtained more easily, and more certainly, through the power and control provided by increased knowledge, that is all to the good.

The solution of our difficulties must be looked for by the increase of impartial scientific knowledge in other directions. It is not for us to offer any advice to a section so much our senior as Section F, but this difficulty is much more their problem than ours. It is our social organisation, our statesmanship, our economic system which are at fault when the abundance which is produced cannot be brought to the many who are in need of it. Social and political sciences and even economic science are no doubt applying themselves to this problem, and let us hope they will be able to remove it from an atmosphere of social prejudice and party bias to the calm, truth-seeking atmosphere of pure scientific investigation. Agricultural science can go forward fearlessly to increase knowledge in the good hope and belief that increased knowledge will be in itself a blessing.



REPORTS ON THE STATE OF SCIENCE,  
ETC.

## SEISMOLOGICAL INVESTIGATIONS.

*Forty-first Report of Committee on Seismological Investigations* (Dr. F. J. W. WHIPPLE, *Chairman*; Mr. J. J. SHAW, C.B.E., *Secretary*; Miss E. F. BELLAMY, M.A., Prof. P. G. H. BOSWELL, O.B.E., F.R.S., Dr. A. T. J. DOLLAR, Prof. G. R. GOLDSBROUGH, F.R.S., Dr. WILFRED HALL, Mr. J. S. HUGHES, Dr. H. JEFFREYS, F.R.S., Mr. COSMO JOHNS, Dr. A. W. LEE, Prof. E. A. MILNE, M.B.E., F.R.S., Mr. R. D. OLDHAM, F.R.S., Prof. H. H. PLASKETT, F.R.S., Prof. H. C. PLUMMER, F.R.S., Prof. A. O. RANKINE, O.B.E., F.R.S., Rev. J. P. ROWLAND, S.J., Prof. R. A. SAMPSON, F.R.S., Mr. F. J. SCRASE, Dr. H. SHAW, Sir FRANK SMITH, K.C.B., C.B.E., F.R.S., Dr. R. STONELEY, F.R.S., Mr. E. TILLOTSON, Sir G. T. WALKER, C.S.I., F.R.S.).

*Forty-first Report of Committee.*—The Committee met once during the year, on November 29. The annual grant of £100 from the Caird Fund and the special grant of £50 from the same fund were allocated to the maintenance of work on the *International Seismological Summary*. The Committee also voted the sum of £50 from the Gray-Milne Fund for the same purpose. It will be necessary to make like provision for the coming year.

A large metal sphere for use in the determination of epicentral distances has been made by Messrs. C. F. Casella & Co. for the Committee. The diameter of the sphere, which is cast in brass, is 18 in., the weight 68 lb. After the sphere had been machined the positions of seismological observatories were marked by holes and finally the sphere was chromium-plated. The cost of engraving the positions of the stations was borne by the University Observatory, Oxford, and Mrs. H. H. Turner generously provided the greater part of the accessories which are to be used for the determination of epicentral distances and azimuths.

The income of the Gray-Milne Fund is still suffering from the lapse of the dividends due from the Canadian Pacific Railway.

*Gray-Milne Trust Account.*

|                       | £    | s. | d. |                         | £    | s. | d. |
|-----------------------|------|----|----|-------------------------|------|----|----|
| Brought forward . . . | 203  | 5  | 4  | International Seismo-   |      |    |    |
| Trust Income . . .    | 46   | 14 | 10 | logical Summary . . .   | 50   | 0  | 0  |
| Bank Interest . . .   | 1    | 0  | 2  | Operation of Seismo-    |      |    |    |
|                       |      |    |    | graphs . . .            | 10   | 3  | 4  |
|                       |      |    |    | Milne Library . . .     | 1    | 5  | 0  |
|                       |      |    |    | Fire Insurance . . .    | 15   | 0  | 0  |
|                       |      |    |    | Sphere for determina-   |      |    |    |
|                       |      |    |    | tion of epicentral      |      |    |    |
|                       |      |    |    | distances . . .         | 45   | 0  | 0  |
|                       |      |    |    | Postage, etc. . . .     | 3    | 18 | 7  |
|                       |      |    |    | Balance carried forward | 139  | 18 | 5  |
|                       |      |    |    |                         |      |    |    |
|                       | £251 | 0  | 4  |                         | £251 | 0  | 4  |

*Seismographs.*—The six seismographs belonging to the British Association have remained on loan to the seismological stations at Oxford (2), Edinburgh, Perth (W. Australia) and Cape Town (2).

A happy sequel to the efforts of the Committee to further the establishment of a seismological station at St. Louis Observatory in Jersey is to be reported. M. E. Rothé, Director of the Institut de Physique du Globe at Strasbourg, has been so good as to lend a Mainka seismograph to St. Louis. The station, which is being maintained by the Rev. C. Rey, S.J., should prove of great value in studies of the minor earthquakes which are not uncommon in the neighbourhood of the Channel Islands. The nearest existing seismograph stations are Kew and Oxford, about 300 km. away, and Paris, about 330.

At Kew Observatory a second Wood-Anderson seismograph has been taken into use. It may be noted that the two Wood-Anderson seismographs, which record on one drum, were run for a time with a period of about 1 sec. It was found, however, that no significant records were obtained and the instruments were then adjusted to the period of 2.3 sec., enabling distant earthquakes to be recorded clearly. A new seismograph house has been constructed at Kew. It is hoped that the effects of wind which have marred the records of the Galitzin seismographs in the basement of the Observatory will be avoided.

Mr. Shaw reports that the Milne-Shaw seismograph on order for Brisbane has been delivered. A second component has been supplied to Helwan, Cairo. This instrument was equipped with a recording mechanism giving 15 mm. traverse of the film per minute. A duplicate recording unit has been sent to Colaba, Bombay, and a timing clock (second regulator) is being constructed for use with the seismograph at the Upper Air Observatory, Agra, Bombay. Mr. Shaw is also constructing a Milne-Shaw seismograph for the Exhibition of Instruments at the forthcoming meeting of the Union of Geodesy and Geophysics at Edinburgh.

*British Earthquakes.*—There was no considerable earthquake in the British Isles during the year, but small disturbances were reported as occurring on the following dates:

|       |              |   |   |                               |
|-------|--------------|---|---|-------------------------------|
| 1935. | September 25 | . | . | Channel Islands               |
| 1935. | October 24   | . | . | Leigh, Lancashire             |
| 1936. | March 8      | . | . | Glenmoriston, Inverness-shire |
| 1936. | March 11     | . | . | Comrie, Perthshire            |
| 1936. | April 12     | . | . | Strathcarron, Ross-shire      |
| 1936. | May 4        | . | . | Donnybrook, Dublin            |
| 1936. | May 13       | . | . | Strathcarron, Ross-shire      |
| 1936. | June 10      | . | . | Kinlochewe, Ross-shire        |
| 1936. | June 19      | . | . | Derrynane, Cahirciveen, Kerry |
| 1936. | June 19      | . | . | Donnybrook, Dublin            |
| 1936. | June 21      | . | . | Derrynane, Cahirciveen, Kerry |

Dr. Dollar has undertaken to collect observations of any earthquakes which may occur in the British Isles in future. Dr. Dollar is also hoping to publish the collected records of the earthquakes which have occurred in these islands since the Hereford earthquake of January 1924, the last earthquake which finds a place in Dr. Davison's *History of British Earthquakes*.



*Montserrat.*—The earthquakes in the island of Montserrat having continued, a small expedition to the island was organised by the Royal Society, Mr. A. G. MacGregor being the geologist and Dr. C. F. Powell the physicist. Prof. Jaggar of Hawaii and Sir Gerald Lenox-Conyngham also visited the island. Dr. Powell has installed a Wiechert horizontal seismograph as well as a number of Jaggar shock-recorders which were made at Kew Observatory for the expedition. Seismic activity has been much less during the first half of 1936 than during the previous two years.

#### THE INTERNATIONAL SEISMOLOGICAL SUMMARY.

*A Note by Mr. J. S. Hughes.*

The preparation of the *International Seismological Summary* for 1931 has been completed. The sections for the first two quarters of the year have been distributed and the other two sections are with the printer. As was anticipated in the last Report, 1931 proved a very heavy year seismologically. The number of epicentres identified was not exceptionally large, but the earthquakes were more generally observed. For the first six months of 1931 the number of pages required in the *Summary* was 283 as compared with 197 in the previous year; the earthquakes dealt with numbered 297 in 1931, 284 in 1930. It is remarkable that after unusual seismic activity on November 2, 1931, mainly connected with South Japanese shocks, there was a sudden lull, and the spell of reduced activity lasted for about three months.

The only shock occurring in 1931 which calls for special mention, although there are many well-determined earthquakes in the year, is that of August 10. The epicentre  $46^{\circ} \cdot 9$  N.  $90^{\circ} \cdot 0$  E. (near the Great Altai Mountains, Mongolia) is that used in the *Seismological Summary* of the British Association for the earthquakes of 1917, July 31 and November 28, but was adopted only after a separate calculation had shown the position accurate within  $0^{\circ} \cdot 1$ .

The P observations show very good fit with the determination made, but the S readings are nearly all uniformly too large by 30 sec. This means that in the preliminary calculations, when a  $T_0$  dependent on S-P was used, the Japanese and European stations gave separate epicentres with the same time at origin. According to the old routine when it was customary in the *Summary* to keep the balance of S and P residuals at all costs, the shock would probably have been entered as having a  $T_0$  of 21h. 18m. 25s. with a positive or *high* focus correction of  $0 \cdot 030$  or so, leaving the interpretation of the abnormality to seek. Now the abnormality is shown in a different way. In a review of the *International Seismological Summary*, 'Nature,' January 4, 1936, it was stated, 'It is interesting to notice that there were no earthquakes to which it was found necessary to allot high focus. It appears that with more reliable observations and more reliable standard tables the anomalies which led Turner to assume high foci for certain Earthquakes do not occur.' Here we have this anomaly turning up in a very pronounced form; had the differences been of the opposite sign there would have been no hesitation in assuming considerable focal depth.

It is always rather a question whether shocks occurring in the same neighbourhood successively should be regarded as originating at the same epicentre or whether the small differences which can sometimes be deduced from the residuals have a real significance. An interesting case is that of 1931 October 3 and the succeeding days, in which 21 shocks occurred near the Solomon Islands, round about  $10^{\circ}$  S.  $162^{\circ}$  E. In making the determinations of these shocks, six separate epicentres were adopted,



although in the case of some of the smaller shocks it may be that more grouping could have been effected. However, the determinations have been made separately, and only those which prove themselves to be repetitions have been adopted as such.

Another series of shocks occurred on 1931 November 1 and 2 off Shikoku Island, Japan. There were three large shocks, but the waves of the smaller shocks are difficult to allocate to definite epicentres and have been listed under the stations which recorded them.

Work on the data for March 1932 is now in hand, but a number of stations have not yet sent in reports for that year. This is much to be regretted. Even if the reports arrive in time for the observations to be inserted before the copy goes to press the dilatory stations do not pull their weight in the determinations of the epicentres and times of the earthquakes.

### TRANSMISSION TIMES.

*By Dr. Harold Jeffreys.*

The revision of the tables mentioned in the last report has now been published by the Bureau Central de Séismologie. In later work based on the same data, supplemented by estimates of the thicknesses of the upper layers from deep-focus earthquakes and surface waves, and by earthquakes well observed at short distances, I have obtained a formal solution for the times of P so long as it does not cross the  $20^\circ$  discontinuity, and by combining this with the times beyond  $20^\circ$  I have found an estimate of the depth of the discontinuity, which is  $483 \pm 17$  km. below the outer surface, 42 km. of this representing the adopted thickness of the upper layers. Times of P have been calculated for focal depths down to the discontinuity.

The work is now being extended to S and SKS. The difficulty about these pulses is that about  $20^\circ$  and beyond  $70^\circ$  the residuals do not fit the normal law of errors even approximately, and the correct method of treatment is uncertain. At these distances various published tables differ by 10 or 15 secs. A test has been obtained from the deep-focus earthquakes discussed by Scrase and Stechschulte, additional Japanese observations published by Wadati being used in both cases. These give satisfactory series of S observations for rays that have not crossed the discontinuity, and show that up to  $20^\circ$  the times in the Jeffreys-Bullen Tables can be trusted to about 2s. To convert into actual travel times from a surface focus the times of P need to be increased by about 9s., and those of S by about 14s. Beyond  $70^\circ$ , however, a substantial decrease of the times of S (with respect to those up to  $20^\circ$ ) is indicated by these deep-focus earthquakes and a number of normal ones; the same applies to SKS, the difference reaching about 10s. Other material is being incorporated, but a satisfactory separation of the various movements that are read as S cannot be obtained unless the epicentre can be fixed with a standard error of  $0.1^\circ$  or so; and it is not often that a suitable epicentre is associated with a good series of S observations.

Times of  $pP$ ,  $sP$ ,  $sS$ , and  $sSKS$  have been calculated; comparison with observation, however, suggests that the above estimate of 42 km. for the total thickness of the upper layers is about 6 km. too great.

The rise in the velocity of P or S at the  $20^\circ$  discontinuity is about 9 per cent.; Bullen, using the theory of the figure of the earth, finds that an increase of about 10 per cent. in density is also necessary. A suitable material to agree with these values is hard to find, but Dr. J. D. Bernal has suggested an explanation based on the properties of magnesium germanate,

which is chemically very similar to olivine. At ordinary pressures the germanate exists in two forms found by Goldschmidt, a rhombic one analogous to olivine, and a cubic one analogous to spinel, the latter being the denser and therefore likely to predominate at higher pressures. The silicon atom, being smaller than that of germanium, will interfere with the further compression of the oxygen lattice of olivine at a higher pressure, but the next stage can be inferred by analogy, and it appears that the material between the  $20^\circ$  discontinuity and the core is likely to be a cubic form of olivine.

K. E. Bullen, following up his work on the density, is calculating the effect of the ellipticity on the times of transmission. It is smaller if geocentric latitudes are used instead of geographical ones, the difference in extreme cases reaching about 2s. for P; apart from this the effect never reaches 1s. The whole effect does not exceed  $0.4s.$  up to  $30^\circ$ . When this work is complete it will be necessary to correct the present tables to adapt them to a spherical earth, but this will not be difficult.

A comparison of the accuracies of seismological stations has been carried out by means of the P residuals for the best observed earthquakes in the *I.S.S.* from January 1930 to March 1931. The bulk of the best stations appear to attain a standard error in routine observation of 2s. or a little over. This accuracy is reached in Great Britain only by Kew and Oxford. Some of the apparent standard error is due to errors in the epicentres, but not much; most of the *I.S.S.* epicentres indicated by the marks N. 1 and R. 1 appear now to be accurate to  $0.2^\circ$  or less, the probable errors as given being too high. In some earthquakes, however, average standard errors at all stations as low as 1.3s. have been found; I think that this is due to special clearness of these shocks in comparison with others. In the North Sea earthquake of 1931 June 7, for instance, I have redetermined the epicentre from the *I.S.S.* data, obtaining  $53^\circ.95 \pm 0^\circ.05$  N.,  $1^\circ.55 \pm 0^\circ.06$  E.; this makes the P residuals at five of the eight British stations equal to 0 or  $\pm 1s.$ , two equal to  $+2s.$ , and one equal to  $-3s.$  Thus they can attain high accuracy in favourable conditions. The general comparison, however, is useful in selecting stations for a preliminary determination of an epicentre and in adjusting the weights of doubtful observations; for bad observations can occur at even the best stations.

## VERY LONG SEISMIC WAVES.

### *An Editorial Note.*

In examining the records<sup>1</sup> of the great submarine earthquake which occurred in the South Pacific (long.  $156^\circ$  E., lat.  $57^\circ$  S.) on June 26, 1924, W. C. Repetti and J. B. Macelwane noticed certain long waves which they denoted by X and U. The X wave had an enormous amplitude at the nearest stations for which the records were available. At Wellington,  $19^\circ$  from the epicentre, there was an oscillation taking 18 mins. At Sydney,  $23^\circ$  from the epicentre, the oscillation took about 9 mins.; the amplitude on the Wiechert seismograph was several centimetres. At Uccle,  $162^\circ$  from the epicentre, there were trains of about seven waves with a period of a minute. These waves, which had an amplitude of less than a millimetre on the Galitzin records, were judged to have passed  $1\frac{1}{2}$  and  $2\frac{1}{2}$  times round the globe. Repetti found for the velocity of the X waves  $4.51$  km. per

<sup>1</sup> W. C. Repetti, S. J., *Bull. Seism. Soc. Amer.*, **17** (1927), 207; J. B. Macelwane, S. J., *Gerlands B.z. Geophysik*, **28** (1930), 165.



second. In his paper Macelwane expresses some doubts as to the X waves. He asks 'Have we then a single wave group with an enormously rapid decrease in period? Or are we dealing with two or even three distinct wave types all having the same velocity?'

Macelwane himself found evidence for the wave which he denoted by U to which he attributed the velocity 7.5 km. per sec. and thought that this wave was recorded at Eskdalemuir after travelling more than  $2\frac{1}{2}$  times round the globe. Repetti's X wave is discussed in the following note by Dr. Stoneley.

It is to be hoped that further attention will be given to the records of the South Pacific earthquake; the results of an examination of the records from Melbourne, Sydney, Adelaide and Perth which were not seen by Repetti and Macelwane would be of great interest. It would be worth while to inquire whether this submarine earthquake was accompanied by an exceptional tsunami, or so-called tidal wave.

### SURFACE WAVES.

*By Dr. R. Stoneley.*

The recent investigation by Dr. Jeffreys of the constitution of the earth down to the discontinuity that corresponds to  $\Delta = 20^\circ$  in the transit of P has an application to the question of the velocity of propagation of surface waves of long period; the 480 km. of rock above the discontinuity corresponds roughly to a single surface layer, so that estimates can be made of the velocities of Love waves and Rayleigh waves associated with this surface layer. This admittedly crude representation requires for Love waves a minimum group-velocity of 4.6 km./sec., corresponding to a period of about 160 sec.; this is of the order of magnitude of the period of the long waves studied by Fr. Repetti, and the velocity is not far from the 4.51 km./sec. of Repetti's waves. The problem is being further investigated with allowance for continuous variation of elastic properties in the layer; it is, however, desirable that the nature of the Repetti waves should be settled decisively from seismograms.

For Rayleigh waves, the formula developed by Jeffreys by the use of Rayleigh's principle was employed. There is a minimum group-velocity of about 4.0 km./sec., corresponding to a period of 250 sec. There is no mention of these waves in F. J. Scrase's paper on the deep-focus shock of 1931 February 20, although one would expect an earthquake of this focal depth to be favourable to the generation of surface waves of the kinds under consideration. Special search was made, in fact, by Scrase for surface waves, and their absence is as interesting now as their presence would have been had they been found at the time that this earthquake was under consideration.

The problem of Love waves in a triple surface layer has also been investigated; although, as would be expected, it is decidedly more complicated than the problem of a double surface layer, no new theoretical difficulty arises. It was hoped in this way to allow for the presence of a sedimentary layer over the continents. The granitic and intermediate layers were taken to be 14 and 28 km. thick, respectively, and the rigidities of these layers, as well as of the underlying material, were inferred from the velocities of Sg, S\* and S given by investigations on near earthquakes. The corresponding densities were taken as 2.65, 2.85 and 3.4 gm./cm.<sup>3</sup>. Wave velocities of Love waves of various periods were obtained by integration from the observed group velocities. The data for the sedimentary layer are much less



certain : the velocity  $S_s$  was taken as 2.9 km./sec., and the corresponding density 2.5 gm./cm.<sup>3</sup>. On these assumptions the thickness of the sedimentary layer can be calculated. The value of the thickness found, nearly 4 km., is double the thickness that Jeffreys estimates from the denudation needed to account for the sodium in the ocean.

Dr. Jeffreys has pointed out to me that, according to the work of the Geophysical Laboratory at Washington, the rate of increase of the bulk-modulus with pressure is very much greater for pressures less than  $2 \times 10^9$  dynes/cm.<sup>2</sup> (corresponding to a depth of about 8 km.) than for greater pressures ; a corresponding increase in the rigidity probably goes with the increase in the bulk-modulus, and if so, it may not be appropriate to take for the upper part of the granitic layer the elastic constants determined from near earthquakes for that layer as a whole. It may well be that, so far as the velocity of surface waves is concerned, the upper part of the granitic layer has to be reckoned as part of the sedimentary layer. Further, the sedimentary layer almost certainly does not approach homogeneity, and there is considerable doubt as to the density and the elastic constants that should be chosen to represent it ; as the method is rather sensitive to changes in the elastic constants, at any rate for the wave-periods used in this investigation, an accurate determination of the thickness is not to be expected.

#### THE BAFFIN BAY EARTHQUAKE OF 1933, NOVEMBER 20.

*By Dr. A. W. Lee.*

This earthquake was chosen for study because the epicentre was in such a position that the records at the numerous seismological stations of Europe and America would provide material for determining more precisely the travel-times for distances of the order 40°.

A detailed investigation has now been completed and will be published shortly. The records of ninety-nine observatories were collected and examined at Kew Observatory ; over two-thirds of these observatories are at epicentral distances between 25° and 50°.

The epicentre is located as in latitude 73°.3 N., 70°.2 W., and the focus at a depth of about 10 km. ; the time of occurrence of the shock is taken as 23h. 21m. 31.5s. G.M.T.

Comparisons have been made between the observed travel-times for P and S and the times calculated from various tables. The best representation of the travel of the P waves from 25° to 50° is given by a table based upon one published by Gutenberg and Richter ; in this modified table the apparent velocity is uniform for epicentral distances from 25° to 40° and again from 45° to 50°, the velocity changing by 17 per cent. from 40° to 45°. There are discrepancies between the observations of S and the tables of travel-times hitherto available. A new table for S at distances from 25° to 50° has been computed from the travel-times for P on the assumption that Poisson's ratio is constant for the rocks traversed by the waves. The agreement between the observations and this table is satisfactory.

#### REAPPOINTMENT OF THE COMMITTEE.

The Committee asks for reappointment, for the continuation of the normal grant of £100 from the Caird Fund and for a special grant of £50 for the maintenance of the *International Seismological Summary*.

## MATHEMATICAL TABLES.

*Report of Committee on Calculation of Mathematical Tables* (Prof. E. H. NEVILLE, *Chairman*; Prof. A. LODGE, *Vice-Chairman*; Dr. L. J. COMRIE, *Secretary*; Dr. J. R. AIREY, Dr. W. G. BICKLEY, Prof. R. A. FISHER, F.R.S., Dr. J. HENDERSON, Dr. E. L. INCE, Dr. J. O. IRWIN, Dr. J. C. P. MILLER, Mr. F. ROBBINS, Mr. D. H. SADLER, Dr. A. J. THOMPSON, Dr. J. F. TOCHER and Dr. J. WISHART).

*General Activity.*—Seven meetings of the Committee have been held, in London.

| The grant of £200 has been expended as follows:   | £  | s. | d. |
|---|----|----|----|
| Re-interpolation of $K_0(x)$ and $K_1(x)$ for $x = 2.00(0.01)5.00$                                  | 2  | 0  | 0  |
| Completion of calculation of functions $\mathcal{J}_2(x)$ to $\mathcal{J}_{20}(x)$                  | 74 | 5  | 6  |
| Calculation of functions $k_2(x)$ to $k_{20}(x)$ for the range $x = 0$ to $x = 5$                   | 25 | 14 | 6  |
| Calculations connected with the functions $k_2(x)$ to $k_{20}(x)$ for the range $x = 5$ to $x = 20$ | 15 | 0  | 0  |
| Calculations connected with the functions $I_2(x)$ to $I_6(x)$                                      | 2  | 12 | 6  |
| Miscellaneous Bessel function calculations  | 69 | 5  | 6  |
| Secretarial and miscellaneous expenses  | 11 | 2  | 0  |

*Publication of Parts.*—In order to avoid the delay that would occur if small tables were held over till a volume of reasonable size could be issued, it has been decided that some of the future volumes shall be published in parts. These parts will be available separately in paper covers. After the printing of several parts, it is intended that they shall also be made available in cloth-bound volumes.

*Factor Table.*—This volume, containing all the factors of all numbers up to 100,000, was published in December. It constitutes the third volume published at the expense of the Cunningham Bequest.

*Table of Powers.*—The Committee has been very fortunate in receiving, as a gift from Mr. H. J. Woodall, a stereo proof of a table showing all the powers up to the twelfth of all numbers up to 1000, prepared by J. W. L. Glaisher. This table was first mentioned in the Committee's Report for 1873, but for some reason that is not known was never published. A single copy was lent to Cunningham (see *Messenger of Mathematics*, vol. xxxv (1905), p. 22), and passed, on his death, to Mr. Woodall. This is the copy now in the possession of the Committee, and is probably the only copy extant. Inspired by the gift of Glaisher's power table, the Committee has obtained Council authority for the publication of a table of powers, at the expense of the Cunningham Bequest. The proposed contents are  $x^n$ , where:

- (a)  $x = 1-49, n = 1-30(5)50$
- (b)  $x = 50-119, n = 1-20(5)50$
- (c)  $x = 120-249, n = 1-20$
- (d)  $x = 250-1049, n = 1-12$

The work of new calculation and preparation of printer's copy has been begun, under the supervision of Dr. Miller.

*Bessel Functions.*—The completion of Volume VI, containing the four principal functions of order 0 and 1, has been unavoidably delayed. It is expected that it will be published before the end of the year.

Work on the preparation of a second volume, to contain higher integral orders (up to  $n = 20$ ), has continued. Values of  $J_n(x)$ , up to  $x = 25$ , and of  $Y_n(x)$ , i.e.  $x^n K_n(x)$ , up to  $x = 5$ , have been completed, under the supervision of Dr. Comrie. Various fundamental values of  $K_n(x)$  and  $I_n(x)$  have been computed by Dr. Miller and Dr. Bickley, and further work is being supervised by them, and by Dr. Henderson, Dr. Thompson and Mr. Sadler.

*Airy Integral.*—In the Report for 1934 it was stated that the calculation of this integral had been begun, and that the tabular values would be included in the second volume of Bessel functions. In view of requests for earlier publication, it has been decided to complete the calculations as soon as possible; the Council has authorised the separate issue of these tables. The greater part of the work has been done, by Dr. Miller.

*Elliptic Function Tables.*—Several manuscript tables of elliptic functions have been presented to the Committee by the executors of the late R. L. Jones. Dr. Bickley, who examined the tables, reported that they were not suitable for publication by the Committee, as values of the complete elliptic integrals  $K$  and  $E$  to ten decimals at interval 0.001 in  $k^2$  are available in tables by Hayashi, while the remaining functions were simple combinations of  $K$  and  $E$ , of rather limited application in electrical standards work. The tables were, therefore, deposited with the National Physical Laboratory, which was already in possession of other allied tables computed by Mr. Jones.

*Sheppard Tables.*—A number of tables prepared by Dr. W. F. Sheppard have been handed to the Committee, and have been examined by a sub-committee consisting of Prof. Fisher, Dr. Irwin and Dr. Wishart. The main table is one giving the ratio of tail area to ordinate of the normal (Gaussian) curve up to 10 standard deviations by tenths, to 24 decimals, together with Taylor series coefficients up to the sixteenth, for interpolation. It is proposed to publish this and some other allied and derived tables.

*Legendre Functions.*—In the Report for 1932 tables of the Legendre functions that had been prepared were described. These consist of 7-figure values of  $P_n(x)$  and their differences up to  $n = 9$  for  $x = 0.00(0.01)1.00$ , up to  $n = 12$  for  $x = 1.00(0.01)6.00$  and up to  $n = 6$  for  $x = 6.0(0.1)11.0$ . Authority for the separate publication of these tables is being sought.

*Reappointment.*—The Committee desires reappointment, with a grant of £200, with which it is hoped to complete the calculations for the next volume of Bessel functions.



## THERMAL CONDUCTIVITIES OF ROCKS.

*Report of Committee appointed to investigate the direct determination of the Thermal Conductivities of Rocks in mines or borings where the temperature gradient has been, or is likely to be, measured* (Dr. EZER GRIFFITHS, F.R.S., *Chairman*; Dr. E. C. BULLARD, Dr. H. JEFFREYS, F.R.S., Dr. E. M. ANDERSON, Prof. W. G. FEARNSIDES, F.R.S., Prof. G. HICKLING, Prof. A. HOLMES, Dr. D. W. PHILLIPS, Prof. J. H. J. POOLE).

## NOTE ON RADIOACTIVITIES OF IGNEOUS ROCKS.

By HAROLD JEFFREYS, F.R.S.

RADIOACTIVITIES of rocks of the same type are far from uniform. The available determinations have been rediscussed in the hope of improving estimates of the mean radioactivities of the crustal layers and obtaining criteria of their accuracy.<sup>1</sup> The general increase of Ra and Th with silica content has been confirmed, but at the same time the variability increases, not only absolutely, but in comparison with the mean. Only the plateau and Pacific basalts show such an approach to uniformity as would entitle us to infer that they have any resemblance to a uniform parent rock. For rocks of the same type from different regions the means vary by much more than can be attributed to random sampling, but the ratio of the standard (mean square) departure from the mean to the mean itself is as nearly constant as we could expect. It appears therefore that this variability relative to the mean can be regarded as a property of the rock type. Like the mean it increases for the sequence dunite—plateau basalt—basalt—granite; though the agreement between the dunites may be accidental. The frequencies agree closely with the hypothesis that the chance of a radioactivity in a range  $dx$  for a rock of given type for a given region is proportional to

$$x^p e^{-(p+1)x/b} dx$$

where  $p$  is a constant for the type, but  $b$  varies with the region. For granites  $p = 2.6$ , basalts, etc.,  $5.0$ , plateau and Pacific basalts,  $30$ . The mean for the region gives the best estimate of  $b$ . The following table gives some estimated means with their standard errors, which are to be regarded as minima, as some of the results are got by combining regions that may turn out to differ systematically when more data are ready. The units are  $10^{-12}$  g/g for Ra,  $10^{-5}$  g/g for Th.

## Granites.

Finland: Ra  $4.66 \pm 0.40$ ; Th  $2.80 \pm 0.24$ .

Alps: Ra  $4.43 \pm 0.68$ ; Th  $3.30 \pm 0.50$ .

Scotland, Ireland, N. America: Ra  $1.59 \pm 0.12$ ; Th  $0.81 \pm 0.08$ .

## Granodiorites.

California: Ra  $1.77 \pm 0.49$ ; Th  $2.35 \pm 0.45$ .

## Gneisses.

Alps: Ra  $3.26 \pm 0.28$ ; Th  $1.75 \pm 0.25$ .

<sup>1</sup> *Gerlands Beiträge zur Geophysik*, vol. 47, 1936, pp. 149–170.

Basalts, etc.

Scotland, Ireland, N. America:  $Ra\ 0.96 \pm 0.06$ ;  $Th\ 0.98 \pm 0.08$ .

England, Germany, France, Hungary:  $Ra\ 1.30 \pm 0.13$ ;  $Th\ 0.88 \pm 0.10$ .

Pacific Islands:  $Ra\ 0.90 \pm 0.03$ ;  $Th\ 0.46 \pm 0.03$ .

Plateau Basalts.  $Ra\ 0.73 \pm 0.03$ ;  $Th\ 0.52 \pm 0.02$ .

Dunites.  $Ra\ 0.40 \pm 0.043$ ;  $Th\ 0.33 \pm 0.035$ .

Eclogites and peridotites, in comparison with the mean, are as variable as granites, or more so.

The results are consistent with granites and basalts being successive stages in differentiation from plateau basalt or something still more basic; but the variability of eclogites and the origin of the known dunites are inconsistent with these rocks being actual specimens of such a parent.

The granites from Cornwall and Hungary are intermediate between the Scottish and Finnish types. The mean radioactivity of the granitic layer is therefore open to considerable doubt; reasons are given in the paper for provisionally preferring the Scottish value.

## REVIEW OF LITERATURE ON GEOTHERMAL METHODS.

Compiled by Dr. D. W. PHILLIPS, from the *Geophysical Abstracts*,  
*U.S. Bureau of Mines*, to whom acknowledgment is due.

### GEOTHERMAL MEASUREMENTS IN THE BOREHOLES (IN RUSSIAN).

By S. KRASKOVSKI.

*Transactions of the Central Geological and Prospecting Institute*, Leningrad,  
no. 8, 1934, pp. 1-43.

In the first chapter the author states in chronological order the results of geothermal measurements in boreholes in Europe, beginning with Erman's investigations (dated 1832). Describing further the results of experiments in boreholes Paruschowitz V and Chuchow (Upper Silesia) he dwells upon Dunker's investigations (1896) and a compendium of all former observations on the subject by Prestwich (1884-85 and 1895). Concerning the measurements of temperature in the upper strata of the earth's crust J. Koenigsberger's works are particularly valuable. He was the first to draw attention to the great practical importance of geothermal measurements; he had such material based on facts and arranged it so that the relationship between the magnitude of the geothermal degree and the geology of the region under investigation became obvious.

An excellent example of this kind is given by the reports of the American investigators, especially by C. E. van Orstrand, whose works are mentioned in the article. Data obtained by the American Petroleum Institute and interpreted by K. Heald deserve also special attention.

In making thermal maps of the region under investigation van Orstrand applied, probably for the first time, the graphic method to elucidate the relation existing between the reciprocal gradient and geological structures. At present we already may in some cases contour a stock of salt or an occurrence of petroleum by geothermal measurements. Of great interest are the investigations in the United States showing anticlinal structure of the oil-fields.

Instruments and apparatus adapted for geothermal measurements in deep borings are described in the third chapter. The fourth contains a detailed description of methods of measurement and enumerates a number

of factors by which the exact results are presented. The last chapter deals with indications of the methods of calculating geothermal gradient and geothermal degrees. A table of geothermal degrees taken from B. Gutenberg's book (*Handbuch der Geophysik*, vol. 2, pp. 1-7, Berlin, 1931) and a list of sixty-four books of reference are added.

In these abstracts the geothermic gradients are differently expressed and the following table will be useful for converting from one standard to another.

### GEOOTHERMIC GRADIENTS.

(Conversion Table.)

| °C./km. | °C./foot. | Metres/1°C. | Metres/1°F. | Feet/1°C. | Feet/1°F. |
|---------|-----------|-------------|-------------|-----------|-----------|
| 5       | 0.00152   | 200.00      | 111.10      | 656.18    | 364.54    |
| 6       | 0.00183   | 166.66      | 92.58       | 546.82    | 303.78    |
| 7       | 0.00213   | 142.86      | 79.36       | 468.70    | 260.39    |
| 8       | 0.00244   | 125.00      | 69.44       | 410.11    | 227.84    |
| 9       | 0.00274   | 111.11      | 61.72       | 364.54    | 202.53    |
| 10      | 0.00305   | 100.00      | 55.55       | 328.09    | 182.27    |
| 11      | 0.00336   | 90.90       | 50.50       | 298.26    | 165.70    |
| 12      | 0.00366   | 83.33       | 46.29       | 273.41    | 151.89    |
| 13      | 0.00397   | 76.92       | 42.63       | 252.38    | 140.21    |
| 14      | 0.00427   | 71.43       | 39.68       | 234.35    | 130.19    |
| 15      | 0.00458   | 66.66       | 37.03       | 218.73    | 121.51    |
| 16      | 0.00488   | 62.50       | 34.72       | 205.06    | 113.92    |
| 17      | 0.00519   | 58.82       | 32.67       | 192.99    | 107.22    |
| 18      | 0.00549   | 55.55       | 30.86       | 182.29    | 101.26    |
| 19      | 0.00580   | 52.63       | 29.24       | 172.68    | 95.93     |
| 20      | 0.00610   | 50.00       | 27.77       | 164.05    | 91.14     |
| 22      | 0.00672   | 45.45       | 25.25       | 149.13    | 82.85     |
| 24      | 0.00732   | 41.66       | 23.15       | 136.71    | 75.95     |
| 26      | 0.00794   | 38.46       | 21.32       | 126.19    | 70.11     |
| 28      | 0.00854   | 35.71       | 19.84       | 117.18    | 65.10     |
| 30      | 0.00914   | 33.33       | 18.52       | 109.37    | 60.76     |
| 32      | 0.00976   | 31.25       | 17.36       | 102.53    | 56.96     |
| 34      | 0.01038   | 29.41       | 16.34       | 96.50     | 53.61     |
| 36      | 0.01098   | 27.77       | 15.43       | 91.15     | 50.63     |
| 38      | 0.01160   | 26.32       | 14.62       | 86.34     | 47.97     |
| 40      | 0.01219   | 25.00       | 13.89       | 82.02     | 45.57     |
| 45      | 0.01373   | 22.22       | 12.34       | 72.91     | 40.50     |
| 50      | 0.01524   | 20.00       | 11.11       | 65.62     | 36.54     |
| 60      | 0.01829   | 16.66       | 9.26        | 54.68     | 30.38     |
| 70      | 0.02134   | 14.29       | 7.94        | 46.87     | 26.04     |
| 80      | 0.02438   | 12.50       | 6.95        | 41.01     | 22.78     |
| 90      | 0.02743   | 11.11       | 6.17        | 36.45     | 20.25     |
| 100     | 0.03048   | 10.00       | 5.55        | 32.81     | 18.23     |
| 200     | 0.06096   | 5.00        | 2.78        | 16.41     | 9.11      |



## GEOTHERMAL MEASUREMENTS IN THE CITY OF MOSCOW (IN RUSSIAN).

By S. KRASKOVSKI.

*Transactions of the Central Geological and Prospecting Institute, Leningrad,*  
no. 8, 1934, pp. 45-51.

Geothermal measurements in two artesian boreholes on the territory of the City of Moscow were made by the author from July 15 to September 1, 1932. The purpose of these measurements was to find the approximate value of the geothermal degree and to elucidate the influence of casings on the distribution of temperature along the vertical line of the borehole. The results of measurements have shown that one single column of casings does not produce a marked influence on the distribution of temperature.

A value equal to  $38.4 \text{ m.}/^{\circ}\text{C.}$  was obtained for the geothermal degree. This figure is below the normal value and may be explained by the cooling influence of a water-bearing horizon found at a depth of 721 m.

## NORMAL GEOTHERMAL GRADIENT IN UNITED STATES.

By C. E. VAN ORSTRAND.

*Bulletin of the American Association of Petroleum Geologists, Tulsa, Okla.,*  
vol. 19, no. 1, 1934, pp. 78-115.

The objects in compiling this paper have been, first, to prepare a brief summary of the gradients deduced from recent geothermal surveys in the United States; and second, to discuss the data thus summarised from the standpoint of a normal geothermal gradient.

## THE THERMOCOUPLE PROVES USEFUL ON A GEOPHYSICAL SURVEY.

By J. N. A. VAN DEN BOUWHUIJSEN.

*Engineering and Mining Journal, New York, vol. 135, no. 8, 1934, pp. 342-*  
344.

The flow of heat from the earth's centre toward a fixed point close to its surface depends on the heat conductivity of the rock formations between the centre and the point and on the thickness of the different layers. Therefore, according to the author, a shift in the location and a variation in the thickness of the layers would result in differences in temperature when measured across the structure at the same depth.

Thus the horizontal gradient of the temperature in a layer close to the surface should supply some evidence as to the structure of the underlying formations. To prevent the influence of the variations of the atmospheric temperature it is sufficient to measure the temperature at a depth of 1.5 m. Holes drilled for the measurements were about  $1\frac{1}{2}$  inches in diameter.

The experiments were made with thermocouples of special construction, connected to a galvanometer of high sensitivity and sturdy enough to stand transportation in the field.

To determine the value of the new method (thermo-electric method) the author made experiments over two profiles which had previously been well determined by torsion-balance work by Mekel, near Winterswijk, Holland. The results agreed most remarkably with those got by the gravity method. Plans showing the results of temperature measurements and of torsion balance survey are given.

Approximately \$200 would buy all of the instruments. The reading

requires only a few minutes and the crew consists of only two men, one to drill the holes and one observer to take the readings.

### THERMAL CONDUCTIVITIES OF ROCKS.

By H. A. NANCARROW.

Physical Society of London, *Proceedings*, vol. 45, May 1, 1933, pp. 447-461.

The rock specimens are turned as circular cylinders 5 cm. in diameter and 2 cm. high and are bisected by a cut made perpendicular to the base along one diameter. The top of the cylinder is heated and the temperature gradient in the specimen is measured by means of thermocouples held in a mica holder inserted in the cut. The temperature distribution and heat flow in the specimen are each shown to be represented by a series containing Bessel and hyperbolic functions. Constants involved in the arguments of these functions are shown to be dependent upon the loss of heat from the hot surfaces exposed to the air in the apparatus. The determination of these surface heat losses is described. Observations and results are given for four specimens.

### GEOHERMAL METHODS (ON THE DETERMINATION OF THE TEMPERATURE IN THE IMMEDIATE PROXIMITY OF THE EARTH'S SURFACE IN CONSIDERATION OF TECTONIC INVESTIGATIONS).

By W. C. SALM.

*Beiträge zur angewandten Geophysik*, Leipzig, vol. 4, no. 1, 1933, pp. 116-118.

Salm reviews in this article the paper concerning the measurements of the horizontal temperature over the southern border of the Winterswijk horst in Holland, published by Dr. van den Bouwhuisen.

The nine chapters deal with: measurements of the temperature near the surface; description of the instrument; methods of measurement; the conditions of the area under investigation; the results of measurements; the correlation of the observations; considerations on the temperature of the ground; the theory of the distribution of the temperature on both ends of the horst; the determination of the internal conductivity of heat in various rocks; and finally with the verification of the theoretical conclusions by observations.

According to the author, the results obtained agree well with the gravimetric gradients known for this region, as well as with the geological profiles determined by drilling.

### SOME POSSIBLE APPLICATIONS OF GEOTHERMICS TO GEOLOGY.

By C. E. VAN ORSTRAND.

*Bulletin of the American Association of Petroleum Geologists*, Tulsa, vol. 18, no. 1, 1934, pp. 13-38.

The generation and dissipation of heat are important factors in earth history. The present distribution of temperature down to the level of isostatic compensation can probably be determined with more accuracy than has heretofore been obtained by making use of the observations of temperature in tunnels or across mountain ranges.

Recent geothermal surveys show that relatively high temperatures are generally associated with faults, salt domes, sand lenses, and anticlinal structures of both large and small closure.

Radioactivity and thermal condition through oil-bearing strata are shown to be possible sources of temperature variations.

Generation of heat by the oxidation of petroleum appears to be of minor importance as a heat source. The most potent source of heat is to be found in the hot rocks immediately beneath uplifts.

#### TEMPERATURE MEASUREMENTS IN BOREHOLES IN THE VICINITY OF HAMBURG.

By E. KOCH.

*Mitteilungen aus dem Mineralogisch-Geologischen Staatsinstitut in Hamburg*, vol. 14, 1933, pp. 53-80.

Thirty-two temperature measurements made in the boreholes in the vicinity of Hamburg are described in detail. From the results of measurements the geothermal gradient for this region was calculated to be 29 to 39 metres, or a mean value of 34 metres per  $1^{\circ}$  C.

Smaller values (down to  $18.93$ ) were found in the region of an oil-bearing salt dome; higher values (up to  $65.24$ ) were explained by the effect caused by ground waters. The temperature measurements in the Lieth borehole near Elmshorn from 1872 to 1878 are discussed.

#### GEOHERMAL MEASUREMENTS IN ARTESIAN BOREHOLES IN KHARKOV AND MOSCOW DURING THE SUMMER OF 1932.

By S. KRASKOWSKI.

*Beiträge zur angewandten Geophysik*, Leipzig, vol. 4, no. 1, 1933, pp. 76-87.

In the summer of 1932 the author made a number of geothermal observations in the artesian wells in Kharkov and in Moscow. The purpose of the measurements in Kharkov was to investigate the distribution of the temperature in boreholes which penetrated the whole series of Cretaceous layers, the depth of the latter reaching about 550 metres. At the same time, it was desirable to know to what extent the course of the temperature curve was affected by the structural changes in the layers.

The measurements in Moscow were made in one borehole in the yard of the Institute of Geology and Mineralogy and in the borehole of the city slaughterhouse.

From the temperatures obtained it was possible to calculate the geothermal gradient for Moscow and to establish the influence of the tubes inserted in the holes upon the distribution of the temperature.

The difference of the temperature readings in the holes with tubes and without them did not exceed  $\pm 0.2^{\circ}$  C.; that is, the limits of the mean error for ordinary temperature measurements were not surpassed.

#### CONTRIBUTION TO THE HISTORY OF THE GEOTHERMAL GRADIENT.

By H. GEILER.

*Gesch. d. Math., d. Naturwiss. und d. Techn.*, vol. 13, 1931, pp. 352-358.

A historical outline and explanations of the earth's heat are given based on the study of publications by Kayser, Koenigsberger, Sieberg and others.

Factors influencing the geothermal gradient are assembled.



# ROCK TEMPERATURES AND SOME VENTILATION CONDITIONS IN THE MINES OF NORTHERN ONTARIO.

By RALPH H. CLELAND.

*The Canadian Mining and Metallurgical Bulletin*, Montreal, no. 256, 1933,  
pp. 379-407.

This paper is a resumé of a brief survey of rock temperatures made by the Ontario Department of Mines during 1932. Present temperatures were recorded, and the geothermal gradients that now exist were determined.

The geothermometer used is described, and details of instruments for measuring rock temperatures are shown in a diagram.

Geological summaries and temperature conditions in the following districts are given: (1) Porcupine district; (2) Kirkland Lake district; and (3) Sudbury district—Frood mine.

Excerpts from various articles showing rock-temperature conditions in other places are given. The two last chapters deal with the geothermal gradient variations and the underground air conditions.

## THE SIGNIFICANCE OF UNDERGROUND TEMPERATURES.

By M. W. STRONG.

*The Petroleum Times*, London, vol. 30, no. 758, 1933, p. 132.

The author discusses in turn the factors governing underground temperatures and draws a number of conclusions from his studies.

He next discusses chemical action, such as oxidation, hydration, pyritisation, etc. The conductivity difference of rocks is shown to be a major cause of varying gradients, while the effect of diffusivity difference of rocks is important where rapid changes are taking place.

Rapid denudation tends to increase gradients, especially at the surface, while rapid deposition in geosynclines tends toward lower gradients. Squeezing out of incompetent strata also tends to give high gradients. Thrusts and the tectonic piling-up of strata both tend to lower the gradient by burying large masses of rocks at low temperature. As to the upward movement of rock, intrusive salt plugs and igneous masses will increase the gradient. This effect should be sought for only in the late Tertiary strata, unless very large masses have been involved. The effect of late emergence of strata after a long period beneath the sea is that the gradient may be lowered if emergence is in a warm region. The effect of direction of flow of underground waters is determined by topographic, stratigraphic, and tectonic factors, while Quaternary climatic changes may have an important effect on underground temperatures by altering the mean surface temperature.

Special factors are: (a) The loss of heat due to gas escape and oil seepages from oil-fields, and (b) replacement of oil by incoming water. As to (a), this refers to loss by old seepages extending over geological time, and appreciable amounts of heat may be lost in this way whose effect will vary with the porosity and size of the reservoir. As to (b), if the influx is large and from below, increasing temperatures might accompany it; if slow and coming in laterally, this effect might be masked.

## TEMPERATURE MEASUREMENTS IN BOREHOLES IN THE VICINITY OF HAMBURG.

By E. KOCH.

*Mitteilungen aus dem Mineralogisch-Geologischen Staatsinstitut Hamburg,*  
Heft XIV, 1933, pp. 53-80.

The results of thirty-one temperature measurements carried out by the author since 1920 are discussed. Maximum thermometers manufactured by Carl Kramer of Freiburg-i.-Br. were used.

The results of measurements are divided into three groups, according to the geothermal gradients :

1. From 29 to 39 m. per  $1^{\circ}$  C.
2. Less than 29 m. per  $1^{\circ}$  C.
3. More than 39 m. per  $1^{\circ}$  C.

## TAKE TEMPERATURE OF WELL IN JACKSON GAS AREA.

(EDITORIAL NOTE.)

*The Oil Weekly*, Houston, vol. 69, no. 13, 1933, p. 61.

The article gives the readings taken recently by Dr. C. E. van Orstrand in a well in the Jackson (Miss.) gas field, which had gone dead.

The well is Cleve Love et al's Muse-Cotton 1, located 1,360 ft. north and 770 ft. west centre, section 14-5N-1E, Rankin County, south-east part of the field, which is practically on top of the Jackson igneous plug and at the point of maximum magnetic force. The temperature readings were as follows :

| Feet  | $^{\circ}$ F. | Feet  | $^{\circ}$ F. |
|-------|---------------|-------|---------------|
| 100   | 66.4          | 1,250 | 99.5          |
| 250   | 70.8          | 1,500 | 106.6         |
| 500   | 78.1          | 1,750 | 113.7         |
| 750   | 84.2          | 2,000 | 120.6         |
| 1,000 | 93.1          | 2,250 | 126.7         |

## SOME COMMENTS ON THE MEASUREMENTS AND INTERPRETATION OF DEEP-EARTH TEMPERATURES.

By C. E. VAN ORSTRAND.

*Gerlands Beiträge zur Geophysik, Ergänzungshefte für angewandte Geophysik,*  
vol. 3, no. 3, 1933, pp. 261-281.

A brief description is given of the apparatus used by the United States Geological Survey and the American Petroleum Institute in conducting recent geothermal surveys.

As a result of tests in 700 wells located chiefly in producing oil fields, instances have been found in which the isogeothermal surfaces rise in passing over salt domes, faults, sand lenses, and structures of large and small closure. In central Oklahoma, there is in addition to the local variations a regional variation that seems to be determined largely by the depth to the granite.

## UNDERGROUND TEMPERATURE ON A HILL TOP.

By YOSIO KODAIRA.

*The Geophysical Magazine*, Tokyo, vol. 5, no. 1, 1932, pp. 89-95.

The present paper contains the results of mathematical investigations on the underground temperatures observed on a hill top and of those at the same depth in a level tract of land.

## GEOTHERMIC MEASUREMENTS IN WELLS.

BY D. CHAHNAZAROFF.

*Petroleos y Minas*, Buenos Aires, vol. 13, no. 141, 1933, pp. 5-7.

Geothermic measurements in wells can be made by various methods depending on the purpose of observation.

If a thermal survey, by which the thermic horizons of the well are to be determined during one day, is required, an apparatus with automatic registration of temperature should be used; in this case the accuracy of temperature obtained may be equal to 1 to  $1\frac{1}{2}^{\circ}$  C.

If an accuracy of  $\frac{1}{4}^{\circ}$  to  $\frac{1}{3}^{\circ}$  C. is desired, maximum thermometers or open-tube thermometers without a graduation scale must be used; the latter are constructed on the principle that each drop of mercury which flows out of the open end of the thermometer corresponds approximately to  $\frac{1}{3}^{\circ}$  C.; the maximum thermometers are less convenient as more time is required for carrying out the observations. If an accuracy equal to  $\frac{2}{10}^{\circ}$  C. is sought, the thermoelectric method, which is now sufficiently improved, is rapid, and gives accurate results, should be applied.

## THE GEOTHERMIC GRADIENT IN LIMAGNE.

BY G. GRENET.

*Comptes rendus de l'Académie des sciences*, Paris, vol. 195, no. 25, December 5, 1932, pp. 1100-1101.

A 200-metre boring was used for determining the geothermic gradient at Macholles, near Riom. The temperature was measured at a depth of 192.2 m. The geothermic gradient was found to be equal to  $14.16 \text{ m.}/^{\circ}\text{C}$ . The result was in good agreement with the earlier observations at Macholles, confirming the hypothesis that the geothermic degree over the greater part of Limagne is of the order of  $14 \text{ m.}/^{\circ}\text{C}$ .

## ON THE FLOW OF HEAT FROM A ROCK STRATUM IN WHICH HEAT IS BEING GENERATED.

BY C. E. VAN ORSTRAND.

*Journal of the Washington Academy of Sciences*, Baltimore, vol. 22, nos. 20/21, 1932, pp. 529-539.

A mathematical discussion of the question under the assumption that the earth is a cooling globe and that the strata are parallel to the horizontal surface of the ground is given. The results of calculations are represented in curves and tables:

## GEOTHERMAL GRADIENT AT GRASS VALLEY, CALIFORNIA.

BY W. D. JOHNSTON, Jr.

*Journal of the Washington Academy of Sciences*, Washington, vol. 22, no. 10, 1932, pp. 267-271.

Johnston gives in this article the results of temperature observations carried out by him in the gold quartz mines at Grass Valley, California, during 1930 and 1931. The depth-temperature curve, shown in a figure, is slightly concave toward the depth axis. Temperature gradients at the



Empire-Star mine, Grass Valley, Nevada County, are given in a table. According to this table the following values of the reciprocal gradients were established :

From 500 to 1,280 ft.,  $1^{\circ}$  F. for every 168.6 feet

to 2,400 „  $1^{\circ}$  F. „ 175.8 „

to 3,200 „  $1^{\circ}$  F. „ 186.1 „

to 3,700 „  $1^{\circ}$  F. „ 189.8 „

A comparison of temperatures in various deep mines is given in another table, according to which the thermal gradient at Grass Valley is in close agreement with the thermal gradient at the Mother Lode, California, slightly exceeds the gradient in the Rand, South Africa, and is much less than the gradient in the Michigan copper mines and in the St. John del Rey mine, Brazil.

In a footnote Johnston says, 'In A. Knopf's article, "Mother Lode System of California" (*U.S. Geol. Survey*, Prof. Paper 157, pp. 22-23, 1929), a gradient of  $1^{\circ}$  F. for 150 ft. is given. These data have been recalculated by the method of least squares by H. C. Spicer, who obtained a reciprocal gradient of 192.3 ft. per degree Fahrenheit from observations between the depths of 1,575 and 4,200 ft. Knopf's values for the Central Eureka and the Kennedy mines apparently are based on an assumed value of the mean annual temperature  $\bar{Y}$  of the air.'

#### GEOHERMAL GRADIENT OF THE MOTHER LODE BELT, CALIFORNIA.

BY ADOLPH KNOPF.

*Journal of the Washington Academy of Sciences*, Washington, D.C., vol. 22, no. 14, 1932, pp. 389-390.

In this article Knopf offers the following objections to the conclusions contained in W. D. Johnston's article 'Geothermal Gradient at Grass Valley, California' (see the previous article), pointing out two fundamental errors made during the recalculation of the geothermal gradient at the Mother Lode, made by Spicer: 'In the first place temperature observations from two mines (the Plymouth and the Kennedy) situated ten miles apart were used to compute a gradient, but this procedure is not permissible, as the gradients at the two mines are most likely to be different. In the second place it was assumed that the collars of the shafts of the two mines are at the same altitude; the collar of the Kennedy shaft is approximately 1,430 ft., whereas that of the Plymouth shaft is about 1,100 ft. above sea level.'

A reply in explanation of his conclusions is given by W. D. Johnston in an article published in the same number of the *Journal of the Washington Academy of Sciences*, pp. 390-393.

#### GEOHERMAL MEASUREMENTS IN THE BOREHOLES OF THE DONETZ BASIN.

BY S. KRASKOWSKI.

*Gerlands Beiträge zur Geophysik, Ergänzungshefte der angewandten Geophysik*, Leipzig, vol. 3, no. 1, 1932, pp. 9-28.

In the autumn of 1931 the Central Scientific Institution of Geology and Geophysical Prospection in Leningrad carried out an experimental thermosurvey in the deep drill holes of the Stalin district in the Donetz Basin.

The apparatus used by the geothermical section of the institution was constructed by members themselves and consisted of a winch with steel-

wire and tripod, steel thermometer tubes, and a set of maximum thermometers. The distribution of the temperature was investigated in five drill holes. Two of these holes belonged to the region of the future 'shaft 100,' where mining will take place at a depth of 1,200 m. (4,000 ft.); thus it was very important to determine the temperature in advance. The influence of the water in the hole on the normal distribution of the temperature was determined by preliminary observations in two drill holes: the gradient of temperature did not exceed  $0.39^{\circ}\text{C./m.}$  in the first hole and  $0.26^{\circ}\text{C./m.}$  in the second hole. The temperature curves deviated very little from a straight line; these anomalies could be explained by the influence of water layers, thermal conductivity, convection currents, etc.

The importance of the analysis of the temperature curve in geothermic investigations is very great; therefore it is imperative to determine the thermal conductivity of the rock samples in addition to the thermometric observations.

#### RECENT GEOTHERMAL MEASUREMENTS IN THE MICHIGAN COPPER DISTRICT.

BY JAMES FISCHER, L. R. INGERSOLL AND HARRY VIVIAN.

*The American Institute of Mining and Metallurgical Engineers*, New York, Technical Publication No. 481, 1932, 11 pp.

Considerations of heat conduction guided the measurements made to determine the actual virgin temperatures at the 'temperature stations.' Holes in which were inserted one or more thermometers were drilled a few inches back from the breast. Mercury-in-glass thermometers were chosen, mainly because of their simplicity and reliability. Two, and sometimes three, thermometers were inserted in these holes, and were read at 2-hour intervals until three or four readings had been taken. This proceeding was repeated over a number of days. It was found that reliable readings were obtained without waiting until some days after drilling and in spite of nearby blasting.

The conclusions drawn by the authors read as follows: 'Temperature measurements in eight special drill holes in the Calumet and Hecla mines, together with one in an old hole which has suffered no appreciable temperature change in ten years, all fall very nearly on a straight line. The temperatures range from  $74.75^{\circ}\text{F.}$  at 3,562 ft. below the surface to  $95.31^{\circ}$  at 5,679 ft. When taken in connection with Lane's value of  $43^{\circ}$  for the mean surface temperature, these give an average temperature gradient of  $1^{\circ}\text{F.}$  in 108.5 ft., or  $1^{\circ}\text{C.}$  in 59.5 m., which is only about one-half of the Kelvin average for the whole earth ( $1^{\circ}$  in 27.76 m.). The gradient at an average depth of 4,500 ft. is  $1^{\circ}\text{F.}$  in 103.1 ft.

'The data are not sufficient as yet to allow any positive conclusions as to the time and extent of the glacial epochs, but point strongly to a value at least as large as 30,000 years as the time which has elapsed since the last epoch.'

#### MATHEMATICAL THEORY OF HEAT FLOW IN THE EARTH'S CRUST.

BY DAVID OTTO EHRENBURG.

*University of Colorado Bulletin*, Boulder, vol. 32, no. 12, May 1932; *The University of Colorado Studies*, vol. 19, no. 3, 1932, pp. 327-355.

In the introduction to the mathematical discussion of the theory of heat flow in the earth's crust given in this article, the author refers to Ingersoll

and Zobel's application to physical geology of the mathematical theory of heat conduction in homogeneous media, and calculation by them of a number of curves for the cooling of lavas and laccoliths. Ehrenburg continues :

'Unfortunately, their results are based on the narrowing assumption that the thermal constants of the cooling mass are identical with the constants of the underlying or surrounding rock. However, the shape of a cooling curve depends not only upon the configuration of the bodies between which the heat transfer occurs and their initial temperature difference, but also upon the relative values of conductivity, density and specific heat. The writer believes that the difference in thermal constants is an important factor in modifying the character of a temperature curve; and in this paper is proposed a new method of treating the flow of heat in two heterogeneous solids in contact, and also is demonstrated its application to several particular cases similar to those treated by Ingersoll and Zobel.'

#### RATE OF TEMPERATURE CHANGE.

(EDITORIAL NOTE.)

*The Oil and Gas Journal*, Tulsa, vol. 31, no. 3, 1932, p. 109.

In this article temperature gradients for a series of measurements are enumerated. In certain wells in Pennsylvania the temperature gradient indicated an increase of  $1^{\circ}$  F. for each 58 to 64 ft. of depth, and in California an increase of  $1^{\circ}$  for each 52 ft. is often observed. Other temperature investigations show that in some districts the temperature rises at an even faster rate, often at  $1^{\circ}$  for each 40 ft.

In the Salt Creek field in Wyoming well temperatures at a depth of 100 ft. ranged from  $51.4^{\circ}$  to  $65.27^{\circ}$  F., and at 2,000 ft. they ran from  $79^{\circ}$  to  $98.4^{\circ}$ . Temperature measurements in a well in the Teapot Dome field, Wyoming, showed  $71.6^{\circ}$  at 1,000 ft. and  $125^{\circ}$  at 2,867 ft. In another well in the same field the temperature at 25 ft. was found to be  $76^{\circ}$ , but at 2,790 ft. it was  $124.5^{\circ}$ . A completely dry well in the Teapot Dome field showed a temperature of  $52^{\circ}$  at 100 ft. and of  $101^{\circ}$  at 2,000 ft. In wells in California the temperature at 4,000 ft. varied between  $150^{\circ}$  and  $170^{\circ}$ . A thermometer run to the bottom of a well 4,050 ft. deep in the Wellington-Fort Collins area of Colorado recorded  $157^{\circ}$ . This was  $3^{\circ}$  higher than that registered by a well 7,900 ft. deep near Kane, Pa.

Temperature measurements made by E. M. Hawtoff, of the Bureau of Economic Geology, in a well in the Big Lake field in Reagan County, Tex., showed the following temperatures at depths below 5,000 ft. : At 5,700 ft.,  $122^{\circ}$  F. ; 6,500 ft.,  $135^{\circ}$  ; 7,000 ft.,  $152^{\circ}$  ; 8,000 ft.,  $161^{\circ}$  ; 8,300 ft.,  $170^{\circ}$ .

#### TEMPERATURE OF FORMATION OF AN EPI-THERMAL ORE DEPOSIT.

By H. C. BOYDELL.

*Bulletin of the Institution of Mining and Metallurgy*, London, nos. 331 and 332, 1932, pp. 1-43 and 25-39.

This paper was presented at the seventh ordinary general meeting of the forty-first session of the Institution, held on April 21, 1932. In this article a discussion of the paper is given.

The present paper provided a striking example of a problem in mining



geology attacked by the mathematical method, and in that respect it was not only novel but almost unique.

The paper inquired into 'The extent of temperature rise produced by a lava flow on underlying rock, and the influence of such heating on an ore deposit formed there.'

An actual example, namely the Camp Bird gold mine in south-west Colorado, had been chosen by Boydell for his investigations.

The Camp Bird deposit is briefly described. In the summary given by the author, Boydell enumerates the conclusions drawn from his investigations.

#### RESULTS OF WELL TEMPERATURE TESTS IN WYOMING.

BY BRAVITY TAYLOR.

*The Petroleum Engineer*, Dallas, Tex., vol. 3, no. 8, 1932, p. 64.

The author gives a brief description of a series of experiments carried out by the State oil and gas inspector of Wyoming relative to the temperatures obtained in wells in that State.

The description of the apparatus used to obtain temperature measurements in wells with the accuracy required for a study of this nature is accompanied by an illustration.

The operation of the apparatus is explained.

The average run of well-bottom temperatures in Wyoming has been found, according to the experiments, to be between  $90^{\circ}$  and  $180^{\circ}$ . It has been found that the time element in taking temperatures is a very important one. The deepest well in Wyoming, at 8,725 ft. in the second Wall Creek sand, was found to have a temperature of  $140^{\circ}$ .

#### RELATION OF EARTH TEMPERATURES TO GEOLOGICAL STRUCTURE.

BY JOHN A. McCUTCHIN.

*The Oil Weekly*, Houston, vol. 65, no. 2, 1932, pp. 21-26.

The purpose of this research has been to determine the possibility of using temperature data for the location of future oil pools, particularly in areas where the generally used geological and geophysical methods meet with little success.

Detailed temperature surveys have been made by the author in over 300 wells located in forty oil-fields of Oklahoma and Kansas. While the relations in any field in these areas are practically the same, the relations of earth temperatures to geologic structure in the Dilworth field of Kay County, Okla., have been chosen to illustrate the possibilities of using earth temperatures to locate oil-fields. A brief history of the study of earth temperatures and a description of method and apparatus are given. According to two parts of a plate added to the article, a marked relation between geologic structure and the present observed position of the isothermal surfaces in the south dome of the Dilworth field is shown.

The author concludes: 'The results of the temperature observations made in the Dilworth field and in many other fields of Oklahoma and Kansas indicate that this problem has commercial possibilities as a new geophysical method of locating buried structure. It is to be remembered, however, that all these observations have been made in proved fields and abandoned wells and until the method has been tried in a new area, either by making temperature observations in core drill holes or drilling wells, it will remain as a possibility and not as a proved fact.'

## REPORT OF FOUR YEARS' STUDY OF EARTH TEMPERATURES IN WELLS.

BY CHARLES E. KERN.

*The Oil and Gas Journal*, Tulsa, vol. 29, No. 33, 1931, pp. 54 and 104.

This report, made to the American Petroleum Institute, covers four years of work to indicate a possible method for assisting in the location of oil domes.

The recording of earth temperatures undertaken with the financial support of the American Petroleum Institute has been under the general supervision of van Orstrand, who initiated, about ten years ago, the geothermal method for locating oil domes.

Temperature tests taken in approximately 350 oil wells in Texas, Oklahoma, California, and New Mexico have served as foundations for drawing maps and diagrams. They show the relation between temperature and structure in many instances.

The difficulties in interpreting thermal readings are discussed.

## THE COOLING AND TEMPERATURE OF THE EARTH.

BY B. GUTENBERG.

*Sonderdruck aus dem Handbuch der Geophysik*, vol. 2, 1929, 35 pp. Gbrüder Bornträger, Berlin.

This special reprint from the *Handbook of Geophysics*, vol. 2, contains two chapters dealing with the temperature phenomena of the earth :

Chapter 1. Facts based on observations.

Chapter 2. Theoretical considerations.

The following items are discussed in chapter 1.

1. *Measurement of temperature inside the earth's crust.*—Means of measurement are explained and figures showing the results of a series of measurements are given.

2. *The geothermal degree.*—Tables showing the geothermal degrees in various countries and at various depths are given, and the causes of the variation of these degrees are discussed.

3. *Heat conductivity of rocks.*—Two tables, one showing the heat conductivity as a function of humidity and amount of pores in the rocks and another giving the figures for the heat conductivity of several rocks, as established by various authors, and curves showing the dependency of the heat conductivity on the temperature (according to Wolff) are added.

4. *Specific heat of rocks.*—Figures for a few rocks are given.

5. *Melting temperature and melting heat.*—A table with figures for the constants of melting curves, according to Wolff, and a melting curve for helium, according to Simon, are given.

6. *Temperatures of lavas ; transformation-temperatures.*—Lava temperatures according to Perret, Day, Jaggar and Shepherd are collected in a table.

7. *Radioactive substances and the production of heat by them.*—Two tables showing (1) the production of heat according to the amount of Ra, Th, and K in rocks, and (2) showing the radioactivity of Vesuvius lavas according to Joly are given. In chapter 2, 'Theoretical considerations,' the author discusses :

8. *The cooling of the earth during the pre-geological epochs.*

9. *The cooling of the crystalline earth crust and the temperature resulting*

from this.—Melting curves according to Wolff; curves showing the cooling of spherical bodies of various substances representing the earth, in one million years, starting with a temperature of  $100^{\circ}$ , according to van Orstrand; and curves of the temperature inside the earth's crust according to Jeffreys, Adams, Wolff, and Gutenberg are given.

10. *The temperature of the earth's crust based on statical observations.*—As a final conclusion the author gives the following probable figures for the temperatures inside of the earth:

|                       |               |                 |                 |                 |                       |
|-----------------------|---------------|-----------------|-----------------|-----------------|-----------------------|
| Depth, km. . . . .    | 20            | 100             | 200             | 500             | 6,370                 |
| Temperature . . . . . | $600^{\circ}$ | $1,400^{\circ}$ | $1,600^{\circ}$ | $1,800^{\circ}$ | $2,000-5,000^{\circ}$ |

### GEOTHERMAL METHOD OF PROSPECTING.

BY C. L. ALEXANIAN.

Extract from *Traité pratique de prospection géophysique* (Practical treatise on geophysical prospecting), by C. L. Alexanian. Librairie Polytechnique Ch. Beranger, 15 Rue des Saints-Pères, Paris, 6.

Values of geothermal gradients are given by the author for the following countries:

|   | Metres   |
|---|----------|
| Pribram (Czechoslovakia) . . . . .                    | 67       |
| Sabountchy (oil region near Baku, U.S.S.R.) . . . . . | 25       |
| Machôlles (Limagne) . . . . .                         | 14       |
| Pechelbronn (Alsace) . . . . .                        | 14 to 21 |
| Los Angeles (California) . . . . .                    | 14       |
| Kutzenhausen (Alsace) . . . . .                       | 7        |

According to Koenigsberger the normal geothermal gradient in case of horizontal layers is about  $34 \text{ m./}^{\circ} \text{C}$ . This value varies greatly in case of inclined or vertical layers.

The possible reasons for the great local anomalies of the geothermal gradient are given by Alexanian as caused by:

1. Deposits originated by heat processes or of volcanic origin.
2. The distribution of heat due to the displacement of various substances in the earth's crust, such as hot springs, mineral waters, and gas.
3. Deposits produced by heat caused by chemical reactions or deposits containing radioactive substances.
4. Thermal conductivity of rocks and tectonic displacements (heat produced by friction).

A list of thermal conductivities of rocks is given.

The last two paragraphs of the article contain a brief description of methods for measuring the temperature of the soil and a method for calculating the temperature gradient.

### GEOTHERMAL VARIATIONS IN COALINGA AREA, FRESNO COUNTY, CALIFORNIA.

BY ANDERS J. CARLSON.

*Bulletin of the American Association of Petroleum Geologists*, Houston, Tex., vol. 15, no. 7, 1931, pp. 829-836.

Variations of isothermal elevations with respect to structure are developed from temperature measurements in fifty-six wells of the Coalinga area.



The comparative trend of isotherms, geologic strata, and ground surface is shown on two vertical sections through the anticlinal structure of the Eastside field. The results indicate that rock temperatures in this vicinity are controlled chiefly by surface topography and thickness of sediments. Definite correlation between relative temperatures and the oil-bearing structure is not evident.

#### RELATIONSHIP BETWEEN THE GEOTHERMAL DEPTH GRADIENT AND THE HEAT CONDUCTIVITY OF ROCKS.

BY H. BORGER.

*Gluckauf*, Essen, vol. 67, no. 17, 1931, pp. 545-551.

The article is divided into two chapters: (1) investigation of the influence of the heat conductivity of rocks upon the geothermal gradient, and (2) heat conductivity of various rocks.

From the investigations on the relationship between the heat conductivity of rocks and the geothermal gradient the author draws the conclusion that geothermal gradients have different values in different rocks deposited in layers and that their ratio depends on the heat conductivity of the different kinds of rocks.

The numerical value of the geothermal gradient inside a certain type of rock depends not only on its capability of conducting heat, but also on the ratio of magnitude of rocks overlying one another.

The author gives examples showing that in rocks, the geothermal gradient of which is high owing to their good heat conductivity, the temperature may be unusually high if the deposits overlying them have a lower heat conductivity. The differences in heat conductivity of single types of rocks are sufficient for the explanation of the unusually high temperatures often observed in salt mines and coal mines, without the necessity of assuming the existence of special sources of heat.

The article is illustrated by four figures.

#### GEOTHERMIC MEASUREMENTS NEAR SURFACE.

BY A. G. R. WHITEHOUSE.

*The Colliery Guardian*, London, vol. 142, no. 3655, 1931, pp. 210-211.

The object of the present observations was to study the relation of surface air temperature to earth temperature at depths up to 30 ft., and to examine the possibility of a more reliable datum for strata-temperature calculations.

The observations were made at Edgbaston in the grounds of the University of Birmingham at a point 453 ft. above Ordnance Datum. The earth thermometers at depths of 1, 4 and 7 ft. were in gravel, the 30-ft. earth thermometer being in soft sandstone.

In Tables I and II are shown: Air and earth temperatures, annual means for the six years, 1924-1929; and annual ranges of temperature of the thermometers, respectively.

From the results of this investigation the author shows that change in mean earth temperature, with increasing depth near the surface, may be distinctly erratic, and that mean air temperature shows no general relationship to mean earth temperature near the surface. The author concludes that, therefore, the only practical datum in this country for calculations of geothermic gradient is the mean air temperature at the surface taken over a long range of years, and that this datum is at the best a very rough one.

GEOTHERMAL PHENOMENA AND GEOLOGICAL HISTORY WITH SPECIAL  
REFERENCE TO OLD STRUCTURES IN GEOTHERMAL EQUILIBRIUM.

BY M. W. STRONG.

*Journal of the Institution of Petroleum Technologists*, vol. 16, no. 86, 1930,  
pp. 889-901.

Geothermal phenomena are discussed in this article under the following headings :

1. *Introduction*.—Thermal conditions to be expected in old structures are considered first. Investigation is continuing with reference to these conditions in young structures where thermal changes may be expected to be still continuing.

2. *Some factors affecting geothermal distribution*.—The conductivity of the rocks and of their fluid contents are the dominant factors determining the thermal conditions. Topographic irregularities must also be taken into consideration. Effects due to the underground movement of water, oil, and gas must be analysed specifically in each case in which they arise.

3. *Conductivities of rocks*.—Approximate conductivities of various rocks and substances are given.

4. *Influence of thermal conductivity of strata on isogeotherms*.—The distribution of heat in and around masses of relatively good and bad thermal conductivity placed in a medium through which heat is flowing is examined by the aid of some diagrams.

5. *Buried hills or anticlinal structures*.—These are considered on the supposition in each instance that the structure is old enough for geothermal equilibrium to have been attained.

6. *Faults and unconformities*.—The distribution of isogeotherms in the neighbourhood of a fault which has thrown badly conducting strata against strata of higher conductivity is considered.

7. *Buried faults and unconformities*.—The thermal distribution above a buried fault by which beds of different conductivities have been brought into contact, the whole lying buried beneath a thick overburden, is considered.

8. *Importance of conductivity determination*.—Determination of the conductivities of the beds should be one of the first objectives of a geothermal survey, as they are the controlling factors determining the geothermal distribution.

9. *Note on topography and isogeotherms*.—The static distribution of temperature under hills is illustrated in a figure. It is shown by the diagrams that in homogeneous horizontal strata topographic irregularities alone would give rise to irregularities of the isothermal contours.

10. *Factor for elevation with respect to sea-level*.—The necessity of measuring the mean surface temperature is mentioned.

11. *Influence of dip on conductivity*.—In some sandstones, especially if micaceous, and in slates and some laminated shales, the conductivity perpendicular to the cleavage may be only about half that parallel to the cleavage so that in some districts allowance must be made for this additional factor.

12. *Some general remarks on static thermal fields* are given.

13. *Presentation of geothermal data*.—It is evident that for the elucidation of geothermal data the data must be presented in the form of isogeotherms drawn on a geological section, together with information regarding the lithology of the several beds.

14. *Gradients and their significance*.—Wide variations in the values of



gradients assembled from temperature measurements in boreholes show the necessity of studying their significance.

15. *Applications of geothermal methods to the study of structures.*—Detailed application of diagrams showing the kinds of thermal fields to be expected must be worked out in each district separately, having regard to local structural and lithological conditions, and no general rules can be given for their use.

The author concludes that with regard to locating oil sands in a given structure by means of temperature there are at present insufficient data on the conductivity of oil-bearing beds in comparison with the conductivity of the same beds when waterlogged or barren, and until these experimental data come to hand geothermal data must be regarded as of use only in so far as they are indicative of structure.

#### GEOTHERMIC GRADIENTS.

BY J. G. FINLAY.

*South African Mining and Engineering Journal*, vol. 41, part ii, no. 2051, 1931, pp. 509-510.

The following brief description of Dr. Haldane's 'Calorimeter' suggested for obtaining a standardised method of measuring rock temperature is given :

The calorimeter consists essentially of a brass tube about 1 in. in diameter, containing a glass tube about  $\frac{1}{2}$  in. in diameter. The space between the glass and brass tubes is packed with dry felt, and the bottom and top of the tube are secured as shown in a sketch. The glass tube is filled with distilled water, a rubber plug is inserted, and the apparatus closed by means of a brass cap. The calorimeter is then placed in a bore hole and kept there for say 18 to 24 hours, when it is quickly withdrawn, unscrewed, and the temperature of the water taken.

An average of over several hundred observations in Europe and America gives what may be called a normal geothermic gradient of approximately 1° F. per 72 ft. descent.

Great departures from this normal figure (Comstock Lode in Nevada, 1° F. for every 33 ft. descent ; Lake Superior copper mines, 1° F. per 250 ft. descent) led to the conclusion that the geothermic gradient is influenced mainly by the following factors :

(a) *Lithological character of strata.*—According to investigations by Dr. Pirow it was found that the temperature gradient was steeper in the shales than in the quartzites and that, generally speaking, the gradient was approximately proportional to the mean conductivity of the rocks. The following table shows conductivity as given in the British Association Report :

| Rock.                | Conductivity, calories/cm. per sec. |
|----------------------|-------------------------------------|
| Granite . . . . .    | 0.0055                              |
| Basalt . . . . .     | 0.0055                              |
| Quartzites . . . . . | 0.0095                              |
| Slate . . . . .      | 0.0030                              |
| Shales . . . . .     | 0.0020                              |
| Gneiss . . . . .     | 0.0051                              |

(b) *Active chemical processes of decomposition.*—Under such circumstances the gradient tends to become steeper.

(c) *Relief of strata.*—It has been demonstrated on several occasions that when observations are taken on high ridges and mountains the gradient is much flatter.



(d) *Presence of large bodies of cool water, adjacent to the strata.*—This factor serves to demonstrate the cooling effect of a large body of water (five miles from the Lake Superior copper mines the gradient is  $1^{\circ}$  F. per 95 ft. ; close to the lake, only  $1^{\circ}$  F. per 250 ft.).

The author concludes that in any part where observations are taken there are many conflicting factors which have to be considered, and the difficulties attendant on arriving at any definite conclusions will be obvious.

DESCRIPTION OF APPARATUS FOR THE MEASUREMENT OF TEMPERATURES IN DEEP WELLS ; ALSO, SOME SUGGESTIONS IN REGARD TO THE OPERATION OF THE APPARATUS, AND METHODS OF REDUCTION AND VERIFICATION OF THE OBSERVATIONS.

BY C. E. VAN ORSTRAND.

*American Petroleum Institute, Bulletin 205, 1930, pp. 9-18.*

In a brief introduction to the article van Orstrand says that of the various methods that have been proposed for the measurement of temperature in deep wells, two only, the electrical resistance thermometer method and the mercury maximum thermometer method, have yielded results of sufficient importance from the standpoint of efficiency and accuracy to justify their use in making an extended temperature survey.

These two methods are described in this article.

The advantages of the electrical resistance thermometer method over the mercury maximum thermometer method are, according to the author, so great that it will undoubtedly come into general use as soon as the main obstacles—the initial expense of the necessary equipment and the difficulty of constructing leads that will remain intact after being immersed in a mixture of crude oil and salt water—are overcome.

The results of the tests carried out by this method are shown in a depth-temperature curve of a deep well, E. T. Price No. 9, South Penn Oil Co. From this figure the minute details of the temperature distribution are put in evidence. A brief description of the apparatus is given.

The mercury maximum thermometer method has the disadvantage of being slow and tedious. Its chief advantages are minimum initial expense and the certainty of obtaining an accuracy of rather less than  $0.3^{\circ}$  F., regardless of the fluid contents of the well. The two methods of handling maximum thermometers : (1) by means of the bailer and (2) by means of a hand-operated machine, are described. Thermometer holder and containers, as well as other pieces of apparatus, and several views of the hand-operated machine are given in a series of pictures.

The second part of the article deals with some suggestions in regard to the operation of the temperature apparatus : (a) Tests with the oil well machinery, and (b) tests with a hand-operated machine. The operation is explained and the elimination of the chief sources of error in handling the thermometers is mentioned.

The last chapter of the article deals with some suggestions in regard to the correction and verification of the observed temperature data. The possibility of accurate location of the isogeothermal surfaces owing to the difficulty of obtaining a correct answer whether the well is in temperature equilibrium or not is discussed.

In conclusion the author makes statements in regard to the accuracy with which the isogeothermal surfaces can be determined ; he says : ' That they are smooth uniform surfaces before the drill penetrates the pay sands

cannot be denied. The real problem, therefore, is the location of these surfaces in their undisturbed condition. Barring the perturbations produced by flowing fluids previously discussed, there remains the instrumental errors of observation.'

The errors in depth to the isothermal surface resulting from instrumental errors are estimated.

#### RESULTS OF DEEP WELL TEMPERATURE MEASUREMENTS IN TEXAS.

BY E. M. HAWTOF.

*American Petroleum Institute, Bulletin 205, October 1930, pp. 62-108.*

This paper presents a summary of the work of the writer carried out between the dates March, 1927, to January 1, 1929. During this period temperature measurements in deep wells were made in each of the oil yielding provinces of Texas, including the Gulf Coast salt dome province, the interior salt dome province of East Texas, the Luling-Mexia-Powell fault zone province, the Bend Arch, the Panhandle, the Permian Basin of West Texas and South-West Texas.

A general picture of the geothermal conditions has been secured, which should not only justify certain preliminary conclusions, but should also permit effective planning and conduct of further and more detailed work in selected areas.

*Equipment.*—The apparatus used in making temperature surveys was modelled on that described by Van Orstrand. Photographs of the apparatus are given.

*Stem correction for maximum thermometer.*—All tests were corrected using the stem correction given by the U.S. Bureau of Standards. This correction may amount to as much as 1° F. in deep tests, although it is commonly much less.

*Difficulty in securing suitable wells* owing to their usually unsettled conditions is noticed.

*Geological conditions dealt with.*—The wells in which temperatures were taken ranged in depth from less than 1,000 to more than 8,000 ft. ; thus a wide range of different structural types was covered by the work. Some idea of the regional structural conditions is given in a map of Texas showing by structural contours the writer's interpretation of the structural conditions, the location of wells that yielded results of particular interest, and the number of feet of depth which, in each of the wells indicated, resulted in an increase in temperature of 1° F.

A series of maps, cross sections and depth-temperature curves illustrate the article.

Original field notes and temperature tests carried out during this work, showing the country, field, company, well, name and number are given in an appendix.

#### GEOHERMAL CONDITIONS IN OIL-PRODUCING AREAS OF CALIFORNIA.

BY ANDERS J. CARLSON.

*American Petroleum Institute, Bulletin 205, October 1930, pp. 109-139.*

This report is a summary of work done in the Santa Fé Springs and Long Beach fields of the Los Angeles Basin. The results are particularly significant only in respect to relations between earth temperatures and local anticlinal structure of the Santa Fé Springs and Long Beach types.

The apparatus used was patterned after that designed by van Orstrand with some changes made to facilitate operation of the equipment. A depth of 5,000 ft. has been reached. Under favourable conditions a 4,000-ft. survey could be completed in one day.

The reliability of measurements with this type of apparatus was demonstrated by the re-survey of some wells after a lapse of several months. The comparative average temperatures obtained by the author and by van Orstrand for one well are shown in a table. This check made with different sets of thermometers is so close as to show that satisfactory results can be obtained by this method.

All tests were corrected using the stem correction formulated by the U.S. Bureau of Standards.

Factors affecting measurements are discussed.

In an attempt to determine whether or not a relationship exists between earth temperatures and geologic structure, the author has compared both isogeothermal surfaces and the distribution of reciprocal gradients with geologic structure. He concluded that in general the work in California indicated that the isothermal depth was a more reliable medium of comparison than the reciprocal gradient. This is explained by the fact that shallow temperatures seem to be more seriously affected by artificial conditions than do deep temperatures, and this would tend to affect the gradient of a well to a greater degree than it would the depth of the 100° isotherm.

Geological conditions under which the measurements were made and the types of wells used are described. Temperature determinations in thirty-three wells in the Santa Fé Springs fields were made. The depth-temperature curves for these wells are shown in figures 9 to 41. A table showing the geothermal data is given.

Geothermal data for forty-three wells in Long Beach Oil Field are shown in a table.

Conclusions from the study of the data presented, for both the Santa Fé Springs and Long Beach Oil Fields, are drawn.

#### PREDICTION OF TEMPERATURE INSIDE MOUNTAINS.

BY MARIO BOSSOLASCO.

*Ergänzungshefte für angewandte Geophysik*, vol. 1, no. 2, 1930, pp. 149-155.

After a few remarks on the practical value of different methods for the prediction of the temperature of rocks inside mountains, the author mentions the importance of the position of the strata for the solution of these problems and explains by this the high maximum temperature which was found in the Simplon Tunnel.

He shows that the normal course of the geo-isotherms cannot be affected in a sensible way by hot springs. This is in contradiction to a confirmation made previously.

#### GEOTHERMAL OBSERVATIONS IN THE STEBNIK I WELL.

BY STANISLAW ZYCH.

*Institut de Géophysique et de Météorologie de l'Université de Lwow*, vol. 4, Communication no. 44, 1929, pp. 844-848.

Temperatures measured on December 2, 1927, at different depths in the Stebnik I well (near Boryslaw) are given in a table.



The increase of temperature with the depth is small and distributed regularly. For differences of depth of 50 m. the increase varies between  $0.75$  and  $0.85^{\circ}$  C. The mean geothermal degree is  $63.4$  m.

By comparing this value with those obtained in Boryslaw and Kalusz for the same differences in depth, shown in another table, it was established that the depth temperatures in the Stebnik well are considerably lower. This seems to be related to the fact that salt layers and potassium salt layers are crossed by the wells at a depth from 116 to 859 m. In Kalusz the smallest increase was also observed in the salt layers—that is, between 174 and 261 m. of depth.

#### PREDETERMINATION OF TEMPERATURE OF ROCKS INSIDE MOUNTAIN-MASSIFS.

BY K. PRESSEL.

*Zeitschrift des Vereins deutscher Ingenieure*, vol. 73, no. 5, 1929, pp. 126–164.

The author discusses the important question of determining the temperature of rocks inside mountains. An attempt was made to solve this problem by mathematical calculations. Pressel describes methods in which the experiments are carried out on models. Possibilities of thermal and caloric model experiments are mentioned briefly. A third model experiment, an 'electric' one, is described in more detail. Its usefulness was proved by observations made in two well-known tunnels (Gotthard, Simplon). The results of the latter examination are given.

The following items are discussed: (1) importance of temperature determination; (2) literature on temperature determination; (3) influences upon the temperature inside mountains; (4) thermal model experiment; (5) caloric model experiment; (6) electrical model experiment.

#### GEOHERMAL VARIATIONS IN OIL-FIELDS OF LOS ANGELES, CALIFORNIA.

BY ANDERS J. CARLSON.

*Bulletin of the American Association of Petroleum Geologists*, vol. 14, no. 8, 1930, pp. 997–1011.

Data obtained from temperature measurements in oil wells of the Los Angeles basin are presented, and some causes of abnormal temperature conditions and factors affecting the interpretation of geothermal data are noted. The relations of geothermal gradients and isothermal depths to structure are discussed for the Santa Fè Springs, Long Beach, and Torrance Fields. Variations in the geothermal constants are considered with respect to the geology of the region, and the possible correlative value of temperature data is suggested.

#### THE COURSE OF THE TEMPERATURE IN SANDY SOIL.

BY R. SÜRING.

*Zeitschrift für Geophysik*, vol. 6, nos. 4–7, 1930, pp. 285–291.

In this article the author gives some information on the diurnal course of the temperature in the upper strata, as well as on the yearly temperature distribution at greater depths. The question is discussed under the following headings: (1) the diurnal temperature exchange between the

surface of the earth and the depth of 1 m.; (2) the yearly course of the temperature down to 12 m. of depth; (3) temperature variations at greater depths.

In his résumé the author says :

‘ In representing the diurnal course of the temperature in the upper strata of an almost homogeneous sandy soil it is proved that the distribution of the heat is not as uniform as could be expected. In connection with this the author points out that the vertical temperature gradient in the soil shows several changes during the greatest part of the year; these changes must probably be attributed partly to the distribution of the underground waters and partly to the after-effects of greater air anomalies occurring in the deep strata.’

#### DETERMINATION OF GEOTHERMAL GRADIENTS IN OKLAHOMA.

By JOHN A. McCUTCHIN.

*Bulletin of the American Association of Petroleum Geologists*, vol. 14, no. 5, 1930, pp. 535-555.

This paper deals with the data of geothermal gradients collected from temperature surveys carried on since June 1928, in approximately 150 wells located in twenty-four separated fields in Oklahoma and Kansas. The purpose of this investigation is to determine the possibility of using the temperature data for the location of oil pools.

*Description of methods and apparatus.*—The van Orstrand method has been closely followed in the collection of data. A brief description of the method is given.

*Wells suitable for temperature tests.*—As a rule, the wells that have been drilled with rotary tools are the most unsatisfactory wells in which to make temperature observations because the circulation of the rotary mud in the wells so disturbs the temperature distribution in the formations surrounding the hole that the hole must remain idle for a considerable time (about 30 days) before reliable temperature data can be obtained.

Temperature tests can be made in wells drilled with standard tools at any time the tools are out of the well. Temperature observations should not be made near the bottom of drilling wells as the action of the drill may produce an abnormally high temperature at this point.

*Depth-temperature curves.*—An example of a depth-temperature curve taken from a deep well in the Tonkawa field is shown. Depth-temperature curves representing wells in temperature equilibrium may, for all practical purposes, be considered as straight lines. However, when a close examination is made the curves are seen to be slightly curved at the shallower depths, the curvature increasing with increasing depth.

*Shallow temperatures.*—The most important temperature data in a well are to be obtained from the first 1,000 feet. As the shallow temperatures act as a guide to the reliability of the data from the entire well, they should be given careful consideration by those endeavouring to correlate temperature data from well to well or area to area.

*Explanation of cross sections.*—Variation in depth to the 80°, 90° and 100° F. isothermal surfaces for several places are shown in two figures. The gradient ranges from 1° in 107.0 ft. for the wells located near Oklahoma City to 1° in 36.5 and 40.0 ft. for the wells located near Tulsa and Okemah. Several possibilities as to the reason for this difference are suggested.

An explanation of the table showing the variations in the gradient com-



puted in terms of feet per degree F. for the fields where tests have been made is given.

An explanation is also given of several figures on which are drawn contours on 80° F. isothermal surface for wells of the Garber field, contours on 100° F. isothermal surface for a portion of the Cromwell field, gradient depth to 100° F. for three wells located on the Haverhill, and contours for 100° F. isothermal surface for wells in the Eldorado, Kansas, field.

*Variations in Oklahoma and Kansas fields.*—Temperature observations have been made in twenty-four fields in Oklahoma and Kansas. Since the only wells available for testing happened to be temporarily abandoned when the fields were visited, the data from most of these fields are too meagre for conclusions to be drawn regarding the variation of temperature with geologic structures. However, it is interesting to note that in only two or perhaps three fields the data collected tended to disagree with the findings of van Orstrand's previous work in Wyoming and California ('Some Evidence on the Variation of Temperature with Geologic Structure in Wyoming and California Fields.' *Economic Geology*, vol. 21, no. 2, 1926).

*Other uses for temperature data.*—New and important uses for the accurate temperature data that are being collected in Oklahoma are mentioned.

*Conclusions.*—As a whole, the results obtained in Oklahoma to date on the temperature problem are neither consistent nor inconsistent enough to justify any general conclusions. The results indicate, however, that the problem is not simple and that it will probably be solved by the collection of additional accurate data in the fields and in non-productive areas, supplemented, perhaps, by some careful work on the heat-conducting properties of sedimentary rocks in a well-equipped laboratory.

## MEASUREMENTS OF TEMPERATURE IN BOREHOLES.

BY G. FRIEDEL AND V. MAKOWSKY.

*Le génie civil*, vol. 45, no. 23, 1929, pp. 568-569.

Owing to the fact that the use of medical or other types of maximum thermometers at depths over 1,000 or 1,500 m. requires their inclosure in strong steel boxes and that the indications of the thermometers are to be corrected for high and very uncertain pressures, the use of open-tube thermometers without a graduation scale is proposed. The tube of such a thermometer is cut obliquely at its upper end at an angle of about 45° or a little more to the axis of the tube. The reservoir and the tube are filled with mercury so that the latter may rise to the orifice at a temperature which is certainly below that expected at the point of measurement.

Two or three thermometers prepared in this way can be lowered, protected by a simple sheet-iron box filled with clear water, as the pressure will not have a notable effect on the open tube. The thermometers should be left in the borehole for about 24 hours.

At a depth fixed for the measurements the mercury will rise above the open end of the tube and one part of mercury will escape. After the removal of the thermometers they are heated side by side with a graduated thermometer until the mercury rises again up to the orifice; this moment will show the temperature measured in the hole at the desired depth, and its amount can be read from the graduated thermometer.

Temperature curves obtained from measurements made with this type of thermometer in the potassium mines in Alsace and in the saliferous basin



of the Upper Rhine differed from those obtained previously. The curves showing the distribution of the temperature at depths exceeding 1,000 m. were almost straight lines, the geothermal degree being almost constant and equal to about 25 m.

#### NOTE ON TEMPERATURE GRADIENTS IN THE PERMIAN BASIN.

BY WALTER B. LANG.

*Journal of the Washington Academy of Sciences*, vol. 20, no. 7, 1930,  
pp. 121-123.

Lang discusses the temperature tests made in one of the wells in New Mexico (Transcontinental-McWhorten No. 1, Sec. 6, T. 3, S., R. 22 E., De Baca County) and notes the influence of halite and anhydrite sediments, which are characteristic for this region, on the temperature gradients.

The varying behaviour of the isogeotherms of any region can be explained by differences of rock conductivity. Owing to the fact that critical data of the sort necessary to determine the influence of rock conductivities in general upon temperature gradients do not exist, the author proposes that, in order to solve the geothermal problem, as many data as possible on the thermal conductivity of rocks as they exist under natural conditions be collected.

#### THE INTERNAL TEMPERATURE OF THE EARTH'S CRUST

BY FRANK M. GENTRY.

*Science*, vol. 70, no. 1814, 1929, pp. 332-334.

Taking into consideration that the linear gradient of 1° F. in 55 ft. is not satisfactory because it leads to large errors even at shallow depths, and that Kelvin's equation, although of considerable theoretical background, does not take account of internal heating which may arise from causes other than the original molten conditions (such, for example, as those of radioactivity, chemical activity, etc.), Gentry discusses in this article the possibility of obtaining equations to represent the average temperature gradient of the earth's crust.

According to the author the calculations of temperature in the earth's crust made with equations derived by him check exceedingly well, on the whole, with the temperature measurements that have been made by van Orstrand, Hallock and others on the world's deepest wells. He adds that, of course, care must be exercised in applying the formulæ to oil and artesian wells, unless the depth of the source of flow be accurately known, for, if the seepage is from a greater depth than the bottom of the well, the temperature of the discharge will be far higher than the computed quantity. On the other hand, if the well taps a fissure short of the bottom, the temperature of discharge will be less than the computed value. Departures from the computed values may be attributed also to variations in the thermal conductivity of the rock.

#### GEOTHERMAL DETERMINATIONS IN THE WELLS TESP IV IN KALUSZ (IN POLISH)

BY S. ZYCH AND A. TABOR.

*Institut de Géophysique et de Météorologie de l'Université de Lwow* (Poland).  
Communications, vol. 3, no. 32, 1928, pp. 886-892.

The authors give a table showing the temperatures at different depths according to observations made in wells Tesp IV in Kalusz. The figures,

as compared with those obtained in the petroliferous region of Krosno, Boryslaw, and Bitkow, are of great interest.

The mean geothermal degree in Kalusz is  $31.5$  m., a figure which is almost identical with that established by Daly for some other parts in Europe.

In comparison with the temperatures in the wells Kornhaber II, in Boryslaw, an increase of from  $2.6^{\circ}$  at a depth of 200 m. to  $5.6^{\circ}$  at 1,000 m. has been observed.

The authors established that, if compared with temperatures measured at Paruszowice, in Silesia, those at Kalusz are higher at depths greater than 770 m., while at smaller depths the difference is not significant. Prof. Arctowski explains this difference by isostasy.

### GEOTHERMAL GRADIENTS IN ALFÖLD.

BY JOSEF V. SUMEGHY.

*Jahrbuch der Königlichen Ungarischen Geologischen Anstalt*, vol. 28, no. 3, 1929, pp. 276-370.

In the brief preface of this work Sumeghy draws the attention of the readers to the fact that unfortunately not all of the territory of Alföld (the great Hungarian Plain) could be investigated. The geothermic gradients in the Croatian and Slavonian parts of Alföld, as well as in the Banat and Bacska, were not determined. This is especially regrettable owing to the fact that these parts have the greatest number of deep wells, thus the data obtained there would be of great value.

The work is divided into the following chapters :

1. Calculation of the depth stages.
2. Enumeration of the deep wells examined.
3. Reasons for the differences of the geothermal gradients in Alföld.
  - (a) The different heat conductivities of the rocks.
  - (b) The effect of tectonic causes.
  - (c) The effect of heat produced by the decomposition of organic substances.
  - (d) The effect of the occurrence of gas.
  - (e) The effect caused by the air.
  - (f) The effect caused by radium emanations.
  - (g) Other less important effects.
  - (h) The influence of deep water.
4. The geothermal depth zones of the Alföld.
  - (a) The first geothermal depth zone.
  - (b) The second geothermal depth zone.
  - (c) The third geothermal depth zone.
  - (d) The fourth geothermal depth zone.
5. Relation of the geothermal gradients to the structure of the Alföld.
  - (a) The normal geothermal gradient of the Alföld.
  - (b) The higher and lower gradients.
  - (c) The directions and breaking of lines which can be proved to be based on the lower gradients.
  - (d) Transition zones.

A tectonic map of the Alföld and a large number of diagrams and tables are given. A list of 151 titles of the literature used is added.

## DETERMINATION OF GEOTHERMAL GRADIENTS.

BY K. C. HEALD.

*The Oil and Gas Journal*, December 5, 1929, pp. 90, 91, 191, 192.

This paper is a report of progress made in determining the relationship between variations in earth temperatures and oil-field structures.

The research has been undertaken by the American Petroleum Institute in order to determine whether or not chemical reactions between petroleum and other substances really are the causes of abnormally high temperatures—a theory which has been popular with many European students.

Different types of structures have been considered, such as the gentle folds of Oklahoma, the faulted monoclines of the Balcones fault zone of Texas, the compressed and crumpled strata of the California fields, as well as the extreme deformation that occurs around the salt domes of Texas and Louisiana.

The work, which has been in progress since 1927, has been centralised in areas where results will be most significant to the petroleum industry.

*Oklahoma.*

Temperatures were measured in wells extending from about 18 miles east of the town of Okemah to Oklahoma City. A temperature of 100° F. has been observed in a hole less than 1,500 ft. deep near Okemah and at a depth of 4,100 ft. near Oklahoma. The author notes, although it may be pure coincidence, that the rocks slope in the same direction as the 100° temperature line, at a rate only slightly more abrupt. Future work is necessary to establish or disprove this relation.

*Local structure.*—The work in Oklahoma offered an opportunity to learn whether local structures—anticlines and synclines—in gently folded rocks are reflected by the temperatures in those rocks or not. Heald is of the opinion that van Orstrand's earlier work in Wyoming and particularly on the Salt Creek anticline has been substantiated by McCutchin's work in Oklahoma, leaving no doubt that in steeply tilted beds such a reflection can be detected in many cases.

*Chemical action.*—The work in Oklahoma has not yet progressed far enough to justify any definite statements on the theory that temperatures higher than normal will be found above oil-fields because of heat released through chemical reactions involving oil.

*Water circulation.*—The regional picture seems to support the conception that waters deeply buried in a syncline would move up the dip and would result in making the temperatures in the 'up-dip' areas somewhat higher at a given depth below the surface of the ground than are those in the syncline whence the waters came.

*Effects of unconformities.*—No particular study of unconformities has been made in Oklahoma, but conditions there are suitable for determining whether or not unconformities can be detected by temperature measurements.

*Effect of strong faulting.*—Whether the faulting activity may be detected by temperature measurements cannot be determined by the Oklahoma work, since conditions there are not particularly favourable.

*Texas.*

*Stratigraphic conditions.*—Measurements now available almost, if not quite, justify the conclusion that the age of the sediments has nothing to do with the temperature conditions.



*Period of cooling.*—It would seem reasonable to believe that the temperature of the rocks that had been exposed to cooling would be less than that of rocks that had never been exposed. No decisive opinion is yet justifiable.

*Problem of unconformities.*—This problem is mentioned by the author as being a complex one and requiring more study.

*Relation of earth temperature to structure.*—A regional picture constructed to show about half the State indicates a belt of comparatively high temperature along the Balcones-Mexia-Luling fault in which the temperature increases with depth at the rate of  $1^{\circ}$  F. for about 43 ft. In the central region that temperature increases  $1^{\circ}$  F. for each 50 to 60 ft. Farther west and north-west the average rate of increase is less than  $1^{\circ}$  F. for about 100 ft. The few data available for the great basin of west Texas show that the basin cannot be outlined merely by studying the temperature conditions in wells drilled in and near it. For example, in two wells about 25 miles apart, the temperature in one increased at the rate of  $1^{\circ}$  F. for every 84 ft., and in the other  $1^{\circ}$  F. for every 137 ft.

*Big Lake field.*—The structure of Big Lake field is clearly reflected by the temperature measurements.

*Salt domes studied.*—Four domes (three of them in the Gulf Coast region) were observed. The work has shown that, in so far as this type of structure is concerned, the presence or absence of oil has no determinable effect. General outlines of salt domes can, of course, be located by measurements in very shallow drill holes.

*Concentration of heat.*—In neither area has the work been done in sufficient detail to justify conclusions as to the probable conditions responsible for temperature variations.

*Regional metamorphism.*—The idea that the amount of pressure to which a region has been subjected should be reflected in the temperature is not supported by the work in Texas.

### California.

*Geologic conditions.*—The rocks involved in the California measurements represent a very short period of geologic time. In comparing the results of the California work with those obtained in the other States, the author expresses his preliminary impression that time is not a factor having an important influence on temperature variations in the earth.

*Plan of work.*—The Santa Fé Springs field was chosen for exploration, and more than thirty wells have been measured in that field. The data secured in California must be considered dependable, as some of the measurements have been repeated; they were also retested by C. E. van Orstrand, who used different instruments from those employed by A. J. Carlson.

*Results.*—A report giving details of the work has been prepared by A. J. Carlson and is in process of publication by the American Petroleum Institute.

*Relation of temperature to petroleum.*—The work in California has so far contributed nothing to help to decide whether or not petroleum itself is directly or indirectly responsible for abnormal earth temperatures.

*Relation of temperature to circulating waters.*—Although some of the fields of the San Joaquin Valley have been studied in detail so that it is possible to outline with reasonable accuracy areas in which certain sands contain waters that are moving downward from the outcrop and other areas where the waters are either standing still or are moving up towards the outcrop, no temperature work has been done in these areas as yet.

NOTE CONCERNING THE TAKING OF MEASUREMENTS OF TEMPERATURE  
IN BOREHOLES.

BY I. ATANASIU.

*Annales des mines de Roumanie*, nos. 7-12, July-December, 1928,  
pp. 219-225.

The purpose of the present article is to discuss the conditions under which the temperature measurements can be used as a means of determining occlusions produced by cementation.

The author divides the article into the following sections :

1. General considerations on the variation of the temperature in the ground.
2. What can be obtained by taking the measurements of temperature in the boreholes.
3. Conditions which the thermometers must satisfy.
4. Proposals for applying the measurements of temperature in boreholes.

In section one, Atanasiu gives a formula according to which a geothermic degree—that is, the number of metres to which the thermometer must be lowered in order to reach an increase of temperature of 1 degree—can be calculated :  $Gr = \frac{h}{t - t_0}$ . Here  $Gr$  is the geothermic degree,  $h$  the depth at which the temperature is measured,  $t$  the temperature obtained, and  $t_0$  the mean annual temperature of the ground.

In section two the author gives a table of measurements taken at different depths, which are given in metres in the table :

| Oil Fields          | Depth of Borehole | Temperature | Geothermic degree | Remarks       |
|---------------------|-------------------|-------------|-------------------|---------------|
| 1. Filipesti . . .  | 886               | 37.4°       | 32.6 m.           | Without oil   |
| 2. Campina . . .    | 831               | 37.4°       | 30.5 m.           | In boring     |
| 3. Moinesti . . .   | 900               | 33.7°       | 36.4 m.           | Gas, water    |
| 4. Luncacesti-Zames | 480               | 21.5°       | 38.4 m.           | Surface water |

If the occlusion is not good the water coming from above, which is colder, will lower the temperature, and the geothermic degree calculated will accordingly be higher than the normal one for the region.

This is plainly shown in the table in the case of Luncacesti-Zames.

Temperature measurements may be useful for the determination of the origin of water appearing in the boreholes. For example, if the occlusion is no longer perfect, it is often difficult to be sure whether the water is originally in the deposit itself or comes from above.

By introducing a thermometer the source of the water can be established with certainty, for the temperature will remain constant or be higher in the first case and will drop in the second case.

Section three deals with the construction and protection of thermometers for use in measurements at great depths. The author proposes to manufacture the following types :

Type I. With a scale of from 10° to 30° for depths up to 500 m.

Type II. With a scale of from 25° to 45° for depths from 500 to 1,000 m.

Type III. With a scale of from 40° to 60° for depths from 1,000 to 1,500 m.

In the last section Atanasiu proposes that temperature measurements be made obligatory ; if taken as often as possible they will furnish valuable material which may serve for generation orientation.

## DETERMINATION OF GEOTHERMAL GRADIENTS IN OIL STRUCTURES.

BY THE AMERICAN PETROLEUM INSTITUTE.

*Oil and Gas Journal*, November 14, 1929, pp. 105-106.

This paper is a report of the research division of the American Petroleum Institute on the progress toward determining geothermal gradients in oil-fields.

The report concerns the Oklahoma, Texas, Santa Fé, and Long Beach fields.

*Oklahoma.*—One of the most outstanding facts in connection with earth temperatures in Oklahoma is the apparent agreement of the dip of the isothermal surfaces and the formations.

The reciprocal gradients vary widely from area to area, but show small variations within the same area. The lowest gradient found was  $1^{\circ}$  F. in 149 ft. (Healdton); the highest,  $1^{\circ}$  F. in  $36\frac{1}{2}$  ft. (Glenn Pool).

Data collected in two fields, Haverhill, Kansas, and Glenn Pool, Okla., indicate that the temperatures are higher at corresponding depths in wells located in the producing area than in wells located outside the producing area.

*Texas.*—Temperature measurements were obtained from wells in all parts of the State. A complete report on the results of the work has been submitted to the American Petroleum Institute. The relationship between the normal rate of increase of temperature and the structure is especially noteworthy in salt domes and in anticlinal structures carrying much underground water.

Temperature measurements obtained in salt domes were especially interesting. The following results were obtained in the Humble Salt Dome, Harris County :

1. At equal depths temperatures are higher on the top of the dome than on the flanks.
2. Rate of increase in the temperature with depth is relatively greater on top of the dome than on the flank.
3. The difference in temperature at the same depth and the greater temperature gradient on top of the dome are found not only near the salt, but also above the salt (at depths of 100 and 250 ft.).
4. Drill holes on top of the salt domes have approximately the same temperatures at equal depths.

*Santa Fé Springs field.*—Fourteen wells were measured, bringing the total number tested to thirty-three. The following conclusions were drawn from the computed data :

1. Depth temperature relations are irregular as compared with other fields.
2. Shallow temperatures vary within rather wide limits. Temperatures at a depth of 100 ft. range from  $65.9$  to  $74.9^{\circ}$  F.
3. The elevations at which a temperature of  $100^{\circ}$  F. occurs define an irregular isothermal surface.
4. Reciprocal gradients computed over the depth interval 100 to 2,000 ft., vary from  $47.5$  to  $56.6$  ft. per degree.
5. Reciprocal gradients recomputed over the same depth interval after eliminating certain abnormal temperatures, show a less pronounced irregularity.



6. The lack of a satisfactory relation between geothermal conditions and structure in this field may be attributed to the following three factors :

- (a) The variation of the gradients within the narrow limits of only a few feet per degree of temperature ;
- (b) The unusual conditions of development and production involving the very close spacing of wells and the flow of large quantities of gas and oil under high pressure ; and
- (c) Natural conditions of ground-water circulation causing the establishment of abnormal shallow temperatures.

*Long Beach field.*—Nineteen wells were measured in this field, making a total of forty-three completed. The total variation of depth to a 100° isothermal surface is about 200 ft. and of reciprocal gradients about 8 ft. per degree. The mean isothermal depth is 1,534 ft. and the mean reciprocal gradient about 53 ft. per degree Fahrenheit.

#### TEMPERATURE GRADIENT IN THE PECHELBRONN OIL-BEARING REGION, LOWER ALSACE : ITS DETERMINATION AND RELATION TO OIL RESERVES.

BY I. O. HAAS AND C. R. HOFFMANN.

*Bulletin of the American Association of Petroleum Geologists*, vol. 13, no. 10, October, 1929, pp. 1257-1275.

The authors summarise their experience in making temperature measurements in oil wells and consider whether it is possible to ascertain the existence of petroleum on the basis of a smaller or a larger temperature gradient.

The article is divided into the following paragraphs :

1. Description and discussion of thermometers used.
2. Possible sources of error in temperature measurements.
3. Carrying out of temperature measurements.
4. Calculation of temperature gradient.
5. Criticism of results obtained.
6. Application of results obtained.
7. Attempt at an explanation of temperature variations. In the abstract of the article given by the authors they say :

‘ Numerous temperature measurements have been made during the last 10 years in the Pechelbronn oil-bearing region, to aid in the search for petroleum deposits.

‘ However, the results of the study of approximately 500 measurements clearly show that the isogeotherms are influenced primarily by the tectonic structure of the Rhine Valley graben. They show a nearly regular rise from the edges to the central part of the graben ; also not uncommonly they approach one another. Such increase of temperature is especially marked in the fault zones.

‘ Seemingly the isotherms are not influenced by larger or smaller oil accumulations ; therefore, the presence of oil cannot be looked upon as the cause of the relatively elevated temperature.

‘ It is perhaps possible to explain the rise of temperature toward the central part of the graben by a gradual change in the nature of the deposits. Coarse-grained sandy beds of the graben edges are gradually replaced toward the centre by increasingly finer sands, and finally by finely laminated marls. It is possible that these finest deposits act as a sort of

protective cover against the loss of heat. This suggestion would also explain the increase of temperature and the accumulation of heat along the faults as it is possible to suppose a stronger increase of temperature in the direction of the dislocation in the strata. This suggestion is strengthened by the fact that the especially high horsts are characterized by temperature maxima on the isothermal map.'

A map of the Northern Pechelbronn oil-fields showing the temperature curves at a depth of 400 m. and their relation to productive oil zones, as well as three cross sections of the oil-fields showing underground temperature curves, are given.

A list of publications on temperature measurements is attached.

### THE TEMPERATURE OF DEEP WATERS IN THE REGION OF PARIS.

BY P. LEMOINE AND R. NASSANS.

*Bulletin du muséum national d'histoire naturelle*, series 2, vol. 1, no. 4, May 1929, pp. 264-280.

In this article the authors sum up a series of data obtained on thermometric measurements of deep waters in wells bored in the region of Paris. They consider these data to be of interest, notwithstanding the lack of certainty that the temperatures taken are sufficiently accurate.

After a brief description of the process by which the geothermic degree (Dg) should be calculated and the influence of the possible errors on its value established, the authors give some data concerning the variations of the geothermic degree in different places, as determined by the following scientists :

Gensanne, who made experiments in 1740 near Belfort, found, according to Becquerel :

|                      |   |   |   |       |                         |
|----------------------|---|---|---|-------|-------------------------|
| At a depth of 101 m. | . | . | . | 12.5° |                         |
| „ 206 m.             | . | . | . | 13.1° | Dg. (101-206) = 17.5 m. |
| „ 308 m.             | . | . | . | 19°   | Dg. (206-308) = 17.6 m. |
| „ 433 m.             | . | . | . | 22.7° | Dg. (308-433) = 33.8 m. |

De Saussure (1785), who took measurements in Switzerland in wells bored in searching for rock salt, obtained these measurements :

|                      |   |   |   |   |       |
|----------------------|---|---|---|---|-------|
| At a depth of 108 m. | . | . | . | . | 14.4° |
| „ 183 m.             | . | . | . | . | 15.6° |
| „ 220 m.             | . | . | . | . | 17.4° |

Corder calculated the geothermic degrees (Dg) given for the following places :

|          |   |   |   |   |   |            |
|----------|---|---|---|---|---|------------|
| Corneaux | . | . | . | . | . | Dg = 36 m. |
| Littry   | . | . | . | . | . | Dg = 19 m. |
| Decize   | . | . | . | . | . | Dg = 15 m. |

By comparing a series of data taken in the wells in Paris and its vicinity, the authors found the mean value of the geothermic degree for the basin of Paris to be 34 m.

Great anomalies were observed in Pressagny-l'Orgueilleux. The temperatures of waters at a depth of 70 m. were found to be 17°, although their normal temperature should be about 13°.

The authors note especially that, by assuming one geothermic degree to be equal to 34 m., the waters of a temperature of 17° should be at a depth of

about 204 m., but none of the wells situated in the region to the north-west of Pressagny was so deep as that.

Whether this anomaly can be explained by the quick rising of deep waters flowing from the region of Paris to Pressagny remains unsolved, and the conclusion of the authors that the waters in Pressagny are supplied from south and east seems to be the most probable one.

Anomalies observed in several other wells were less important.

In several places waters of a temperature lower than the normal one have been observed. The authors, who called these waters 'hypothermal' waters, could not find any explanation for this hypothermality.

A long list of authors giving data for the temperature at different places is added to the article.

#### INTERNAL HEAT OF EARTH IS STUDIED TO ASCERTAIN FACTS ON WHICH TO BASE GEOLOGICAL PRINCIPLES.

BY C. E. VAN ORSTRAND, Geophysicist, Geological Survey.

*The United States Daily*, Washington, D.C., February 15, 1929.

The question of the internal heat of the earth has been studied almost from the time of the establishment of the U.S. Geological Survey in 1879. In 1920 a report on geothermal data, based generally on the observations made by placing a thermometer in the water flowing from the mouth of a well, was published by N. H. Darton. In this report it was noted that in certain areas in eastern South Dakota the rates at which the temperatures increase from the surface downward vary somewhat uniformly from about 1° F. in 20 ft. to approximately 1° F. in 45 ft. But this method of making temperature tests has proved to be unsatisfactory; therefore the author of this article undertook the task of designing and constructing the apparatus necessary for more accurate measurements. Two different types were developed, one of which was based on the electric resistance thermometer, and the other on the mercury thermometer of the maximum type. It has been necessary to abandon the electric method for the present, owing to the fact that the cable that will meet the requirement of withstanding the dissolving action of oil and salt water must be of relatively large diameter, possibly one-half or three-fourths of an inch; it becomes of such weight and proportions that it cannot be manipulated in a deep well without the aid of powerful machinery.

The machine which is being used to-day for lowering mercury thermometers into a well by means of a piano wire consists of a steel frame and reel, a standardised wheel for accurately measuring depths, and a cylindrical cam which distributes the wire on the reel and thus prevents the transmission of impacts to the thermometers as a result of the slipping of the coils of wire on the reel. No power, other than hand-power, is needed. It is a remarkable fact that a machine weighing 58 pounds, exclusive of the piano wire, which weighs 2.7 pounds per 1,000 ft., can be used to sound wells to depths of more than 4,500 ft.

Concerning the question of the value of temperature tests scientists are not yet able to give a definite answer.

It has been assumed ordinarily that during the millions of years of the earth's existence its outer layers have gradually cooled to depths of about 200 miles. In contrast to this hypothesis is the comparatively recent supposition that practically all of the heat of the earth is due to the disintegration of radium. There are at present wide differences of opinion



with regard to the causes of the irregular distributions of heat in the outer layers of the earth's crust. Thus, it has long been known that the temperatures at the same depths in different localities are not the same. For example, at Fairmont, West Va., a temperature of  $170^{\circ}$  F. was found at a depth of 7,500 ft.; while at Longmont, Colo., a temperature of  $212^{\circ}$  F. exists at a depth of only 6,600 ft. In general the rates at which the temperatures increase with the depth vary from the extremely rapid rate of  $1^{\circ}$  F. in 20 ft. (the value found in some of the oil-fields in Wyoming) to  $1^{\circ}$  F. in 200 ft. (gold mines at Johannesburg, South Africa). No serious attempts had been made to explain these variations in the temperature of the rocks at the same depths until the U.S. Geological Survey found in some oil-fields in Wyoming and California that the temperatures of the rocks at given depths were higher than the temperatures found at the same depths in the rocks immediately surrounding the fields.

The peculiar distribution of heat existing in these oil domes is attributed to the radioactivity, or possibly to the chemical reactions within the oil itself. Other investigators sought the explanation in deep-seated intrusive masses, conduction of heat in the rocks, and the migration of waters in deeply buried sands. It is impossible at present to render a final decision as to the merits of all these hypotheses.

Most intensive investigations are conducted to-day in the United States, as a result of co-operation of various organisations, and the author believes that a precise geothermal survey will ultimately provide the facts on which certain fundamental principles of geology may be established.

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## TEACHING OF GEOLOGY IN SCHOOLS.

*Report of the Committee appointed to consider and report on questions affecting the teaching of geology in schools* (Prof. W. W. WATTS, F.R.S., *Chairman*; Prof. A. E. TRUEMAN, *Secretary*; Prof. P. G. H. BOSWELL, O.B.E., F.R.S., Mr. C. P. CHATWIN, Prof. A. H. COX, Miss E. DIX, Prof. G. HICKLING, F.R.S., Prof. W. J. PUGH, Mr. J. A. STEERS, Dr. A. K. WELLS).

ALTHOUGH geology as a school science subject has never been taught so widely as some other sciences, for instance botany or chemistry, its position in the educational system has recently become far worse than in the past. Whether geology be looked upon as an essential part of a liberal education or as part of the training of those who will be concerned with education or research, the present outlook can only be regarded with grave disquiet.

Systematic inquiries made by the Committee reveal the following facts :

There are scarcely twenty secondary schools in England and Wales where geology is taught, even to small numbers of pupils, as a full science subject.

At a few elementary schools a certain amount is taught, but chiefly where inspired by personal interest or where special facilities and encouragement are afforded by a museum in the locality.

In only a very small proportion of training colleges is the subject included in the curriculum for the Teacher's Certificate, and thus very few teachers receive any training in it.

When contrasted with the great expansion of science teaching generally, this neglect becomes more disturbing to the geologist than it would have

been a generation ago. There is now real danger that, apart from those preparing for careers as miners or engineers, there may be very few students in geology at most Universities within the next generation. The reaction of this upon the progress of the science in this country, upon thought, research, and teaching must be disastrous, for it is essential that a science with such wide applications should be kept in growth and vigour by the maintenance of advanced studies and by the recruitment of its exponents over as broad a basis as possible.

### CLAIMS OF GEOLOGY AS A SCHOOL SUBJECT.

For any educated person some acquaintance with the outlines of geology is essential, for some of the most profound changes in thought have resulted from the growth of geological knowledge. This is especially true in relation to the history of life on the earth. While, however, the implications concerning the age of the earth and the antiquity of man are appreciated by the scientific world and by educated laymen, it is probably true to say that the historical background of most people does not extend beyond a few thousand years. Yet the material bases of this knowledge—the land on which people live, the varied scenery which surrounds them, the distribution of soils and of water supplies which control so many of their activities—are matters of daily moment. The distribution of mineral wealth, with its repercussions on the history of mankind and its influence in international affairs, is of fundamental importance in many studies. Such topics, therefore, as the broad outlines of the history and evolution of the earth and of life upon it ought not to be excluded from a general education.

Geology has an appeal to which many students, even quite young ones, readily respond, and an interest then roused and stimulated almost invariably outlasts school-days. It gives a definite practical outlet, takes them out of doors, and provides a pursuit which can be followed in school journeys, in the leisure time of holidays, and through the opportunities afforded by travel. The field of investigation is almost unlimited, and for this reason progress in certain directions must still be closely related to the activity of amateur workers. There is probably no science where the amateur, and even the beginner, have such opportunities for making valuable observations, and in the past the science has been much advanced by them.

There are few parts of Britain which do not afford notable and varied examples of geological phenomena; indeed, many rural areas may be described as natural geological laboratories. It is deplorable that so many scholars learn little of these surroundings. Geology has also the advantage that its materials and equipment are inexpensive, and effective teaching can probably be carried out with less cost than in any other science.

Geology has contacts with every other science, and its study may be advantageously linked with courses in chemistry, biology and geography. It might well be used as a starting-point in the study of science generally.

It is widely recognised that in some sciences taught in schools, particularly in those with very extensive subject matter, the teaching has become narrowly specialised and even dogmatic; there is a danger that a pupil at the end of his science training may have acquired a great body of information but may have had little chance to develop the scientific outlook which is more likely to make him a useful member of the community. Geology probably affords the best chance of encouraging that outlook in pupils even if they do not carry the study of science to a higher stage.

It has been argued that geology, not being a 'fundamental' science like physics and chemistry, is unsuitable for work at the school stage. This



view, however, loses sight of two important factors. Geology is a typical 'observational' science and is much the most easily applied of such sciences. Almost every locality affords facilities for quickening the observing faculties by the collection of significant facts and the drawing of definite conclusions from them. Further, an intelligent interest in the nature of the crust of the earth, its phenomena and their causes, generally comes early, and unless this curiosity can be satisfied it tends to be lost or crowded out by other interests. It is important also that students, while still young, should have an opportunity of realising the existence of sciences other than the so-called fundamental ones, of weighing their attractions, and of considering the possibility of devoting themselves to one or other of them. If attracted to such an extent they will readily and even eagerly face the necessary preliminary work on such subjects as physics, chemistry, biology or others required for the proper pursuit of their own work.

While, on the grounds stated, it may reasonably be urged that geology should form an essential part of any scheme of liberal education, its specialised study at a later stage provides openings for a limited number who desire to make it their profession, as surveyors and prospectors in Britain, in the Empire and in foreign countries. In addition, owing to its numerous practical applications in mining and quarrying, in engineering and in problems of water and oil-supply, etc., some knowledge of geology is of considerable value to boys taking up many different types of career.

#### RECOMMENDATIONS OF THE COMMITTEE.

##### *General.*

The Committee are strongly of the opinion that geology should occupy a more prominent place in science teaching in schools. They believe that this would be in the interests of scientific education. They also consider that it is a necessary step if geological study and research in this country are to retain the position which they have already gained and to which they are entitled.

##### *Elementary Schools.*

The Committee consider that simple geology should be included with other sciences in the curricula of elementary schools of all types, and hold that no course in general science is complete without it. They regard it as no more difficult to introduce than chemistry or physics, and consider that it is specially suitable for introduction in senior schools in many areas. For this reason and to provide competent teachers they would welcome its inclusion in the courses at training colleges.

##### *Secondary Schools.*

In secondary schools the position of geology may be considered (a) as regards courses leading up to the First School Certificate examination, and (b) as regards courses leading to higher examinations.

(a) *First Certificate Stage.*—In the schedules of some of the authorities examining for School Certificate, geology appears as a full science subject and is taken with conspicuous success at a number of schools. While the Committee view this course with approval, they recognise that an overcrowded time-table or other impediments may make it difficult for many schools to introduce full courses of geology before the School Certificate stage. As an alternative they are anxious to see some geology included as part of a general elementary science syllabus in the First School Certificate course.



A course in general science at the School Certificate level, recommended by the investigators appointed by the Secondary Schools Examination Council, has been instituted by several bodies and is under consideration by others. In some cases the scheme involves three sciences—physics, chemistry and biology; in others only two of these. Some of the schemes already approved give geology a place. The Committee agree that the syllabus in general science should not be divided into compartments corresponding with the component sciences, but they strongly support the view that it should cover a unified scheme in which physics, chemistry, biology and geology should figure. They recognise the difficulties of designing any suitable course in such a subject as general science, and they appreciate that for some time the syllabuses must be of an experimental character. They believe, however, that the inclusion of some geology in such experimental syllabuses would be of much service, as it would be very helpful in building up a synthesis of the other sciences.

(b) *Higher School Certificate and other Higher Courses.*—The Committee are strongly of the opinion that the introduction of more formal geological teaching after the First School Certificate stage is a matter of still greater urgency. This is particularly true in the case of students who may expect to proceed to the University. For while the First School Certificate or its equivalent was formerly the basis of matriculation for the great majority of University entrants, most students now stay at school for two further years, covering work which was formerly done in the Intermediate or First Year course at the University. Their choice of subjects is thus made at school, generally from a more limited range than is available at the University; owing to the high standard to which these subjects are carried, students usually find it impracticable to take up any subject with which they have not already made acquaintance. Thus the fact that geology is rarely taught at this stage in schools practically excludes it from the range of subjects from which choice can be made on entering the University. If this higher work is to be done at school, the Committee feel that it is the duty of the schools to provide their pupils with a selection of subjects comparable to that which is available to them at the University.

If, as is suggested in some quarters, the scope of the Higher Certificate examination is made wider, and courses in four subjects are required, these considerations will apply with even greater force. Similarly, if the qualifications for University matriculation are raised and a special examination of a higher standard than that of the First School Certificate is introduced, it is very desirable that geology should be made available as an optional subject, both by the schools and the examining bodies.

#### *Supply of Teachers.*

While it is no doubt true that any great immediate increase in the teaching of geology would be to some extent limited by the lack of suitable teachers, it is not likely that the position would be worse than was the case when other sciences were first introduced; many teachers with geological training are at present teaching geology or other sciences.

#### *Relation of Geology to Geography.*

While the teaching of geology as such has diminished, the Committee recognises that its physical side in many cases has been well taught in the geography classes. They regret, however, that the growth of geographical studies has not led to some corresponding growth in geological teaching. It is true, of course, that many of the most successful teachers of geography have received a training in geology, but the Committee understand that

many teachers of geography are now being trained without an adequate knowledge of geology. The Committee greatly regret that the close relationship between these two subjects is not more generally acknowledged.

As regards school courses in geography, the Committee recommend that the physical side of geography should be well taught in the First School Certificate classes; the correlation of this teaching with the geological part of a general science course should be of great value. In the Higher School Certificate also, geography should normally be linked with some work in geology.

In conclusion the Committee wish gratefully to acknowledge the assistance which they have received in the preparation of this report. In reply to inquiries, a considerable amount of information has been supplied by a number of schoolmasters, inspectors, education officers, museum curators and others.

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## GLACIAL DEPOSITS OF BRUNDON.

*Report of Committee appointed to investigate the bone-bed in the glacial deposits of Brundon, near Sudbury, Suffolk* (Prof. P. G. H. BOSWELL, O.B.E., F.R.S., *Chairman*; Mr. GUY MAYNARD, *Secretary*; Mr. D. F. W. BADEN-POWELL, Mr. J. P. T. BURCHELL, Prof. W. B. R. KING, O.B.E., Mr. J. REID MOIR, Mr. K. P. OAKLEY, Dr. J. D. SOLOMON, Sir A. SMITH WOODWARD, F.R.S.).

EXAMINATION of the bone-bearing level in the gravels at Brundon Pit, Sudbury, Suffolk, on the south side of the Stour Valley, has been carried out under the supervision of Mr. J. Reid Moir during the past eight months, by permission of Mr. P. H. Jordan, who is conducting commercial excavations for gravel on the site. A considerable number of bones and teeth of the larger Pleistocene Mammalia, as well as flint implements closely associated with them, have been recovered. On May 24, 1936, a visit was paid to the pit by some members of the Committee, there being present Profs. P. G. H. Boswell and W. B. R. King, and Messrs. K. P. Oakley, J. Reid Moir, D. F. W. Baden-Powell and G. Maynard. The grant made from the Bernard Hobson Fund in October 1935 has been expended in the employment of a specially instructed workman in clearance of the level at which the bones are found and in transport expenses necessary for the inspection of the work, and it was unanimously agreed, in view of the important character of the site and the finds made, to ask for reappointment and a further grant of £30 to enable the work to be continued. Mr. J. P. T. Burchell was co-opted as a member of the Committee.

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## REPTILE-BEARING OÖLITE, STOW.

*Report of Committee appointed to investigate the reptile-bearing Oölite near Stow on the Wold, subject to the condition that suitable arrangements be made for the disposal of the material* (Sir A. SMITH WOODWARD, F.R.S., *Chairman*; Mr. C. I. GARDINER, *Secretary*; Prof. S. H. REYNOLDS, Dr. W. E. SWINTON).

REPTILIAN bones, first observed by the secretary in 1935, are found in two quarries in the Chipping Norton Limestone (Inferior Oölite, fusca and zigzag hemeræ) near Stow on the Wold, Gloucestershire.

The bones occur in a hard, cream-coloured limestone which is worked for road metal. Fossils other than reptilian remains are not common, but among those from the New Park quarry was *Parkinsonia Neuffensis* (Oppel), kindly determined by Mr. J. W. Tutchet.

The two quarries are the New Park quarry, about  $2\frac{1}{2}$  miles north-west of Stow on the Wold, and the Little Rollright quarry, which lies about a mile west-north-west of Little Compton.

From the Little Rollright quarry a Theropod Dinosaur is represented by an ilium, a pubis, a sacrum, a coracoid, a tooth and a metatarsal. This is probably a *Megalosaurus*.

From the New Park quarry the bones obtained are more varied and interesting. They include remains of:

*Steneosaurus*.—Two examples of the posterior part of the cranium; an upper jaw and the adjacent parts of the cranium; a small portion of the upper jaw with well-preserved teeth; several fragments of the lower jaw; six vertebræ and a large scute.

*Cetiosaurus*?—A well-preserved rib, considerably larger than the mid-dorsal ribs of the big *Megalosaurus* in the Oxford museum, is probably that of a Sauropod dinosaur (? *Cetiosaurus*). Several large fragmentary bones may also be those of Sauropods.

*Stegosaurus*.—The most interesting finds were two dorsal plates of *Stegosaurus*. These specimens were most skilfully extracted from the hard limestone by the preparators in the British Museum (Natural History), Messrs. Barlow and Parsons. The committee is much indebted to them. It also wishes to thank the Keeper of the Geological Department for permitting this work to be done at the Museum. Other specimens remain to be worked out.

The collection is being studied by Prof. S. H. Reynolds, who proposes to publish a description of the more important discoveries. It will then be divided between the British Museum (Natural History) and the Stroud Museum. The whole of the grant of £20 has been expended on the collection and preparation of the fossils.



## CLIMATIC CHANGE.

*Report of Committee appointed to make recommendations to the International Geological Congress for the formation of a Committee to consider geological evidence of climatic change* (Dr. W. B. WRIGHT, *Chairman*; Mr. M. B. COTSWORTH, *Secretary*; Prof. E. B. BAILEY, F.R.S., Prof. W. N. BENSON, Prof. J. K. CHARLESWORTH, Sir LEWIS L. FERMOR, F.R.S., Dr. G. W. GRABHAM, Dr. E. M. KINDLE, Dr. MURRAY MACGREGOR, Dr. A. RAISTRICK, Dr. S. W. WOOLDRIDGE).

(DRAWN UP BY THE CHAIRMAN.)

THE Committee appointed in 1934 has, largely through the energy of its Secretary, assembled from the British Dominions a series of articles on the evidences of climatic change, which it now presents with this report. These contributions, and a consideration of such portions of a widespread literature as it has been possible to consult, suggest that much good might result from an international symposium on the subject. There has been no attempt at such a symposium since the meeting of the International Geological Congress in Stockholm in 1910. Your Committee are of opinion that the volume (*Die Veränderungen, &c.*), published at that meeting has been a great stimulus to research, and consider that the coming meeting at Moscow in 1937 is a peculiarly opportune occasion for repeating the effort, since we may hope for the presence there of many of the Russian workers on the subject. More especially we hope that many of those by whose efforts the science of soil geology has so effectively been given a climatic basis, may have something quite original to contribute.

At the same time the Committee consider that the contributions assembled by their secretary contain many original and valuable observations, besides indicating the trend of thought in various parts of the world. It would like to see at least some of these published, but this might well be done through the agency of the International Geological Congress.

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ZOOLOGICAL RECORD.

*Report of Committee appointed to co-operate with other Sections interested and with the Zoological Society, for the purpose of obtaining support for the 'Zoological Record'* (Sir SIDNEY HARMER, K.B.E., F.R.S., *Chairman*; Dr. W. T. CALMAN, C.B., F.R.S., *Secretary*; Prof. E. S. GOODRICH, F.R.S., Prof. D. M. S. WATSON, F.R.S.).

THE grant of £50 was paid over to the Zoological Society on May 3, 1936, as a contribution towards the cost of preparing and publishing Volume LXXI of the *Zoological Record* for 1934. The statement of the 'Record Fund' in the report of the Council of the Zoological Society for 1935 shows that the balance was practically the same as at the end of the previous year, the sums received from the contributing societies being just sufficient to meet the loss on Vol. LXXI. It is clear that the continuation of the *Zoological Record* is only made possible by the support given to it by the Zoological and other contributing Societies. The Committee accordingly asks for reappointment, with the renewal of the grant of £50.

## ARTEMIA SALINA.

*Report of the Committee appointed to investigate the progressive adaptation to new conditions in Artemia salina (Diploid and Octoploid, Parthenogenetic v. Bisexual)* (Prof. R. A. FISHER, F.R.S., *Chairman*; Dr. K. MATHER, *Secretary*; Dr. J. GRAY, F.R.S., Dr. F. GROSS, Dr. E. S. RUSSELL, O.B.E., Prof. D. M. S. WATSON, F.R.S.).

OWING to the appointment of Dr. F. Gross elsewhere the work has been carried on at the Galton Laboratory by Miss S. B. North under the supervision of Dr. K. Mather.

The work of last year showed, among other things, that different parallel families within strains had different powers of resistance to sodium arsenite poisoning. Consequently it was considered advisable to concentrate attention on families within one strain. The strain chosen was the diploid bisexual form from the Western U.S.A., most of the material coming, in fact, from California. Various substrains were explored and some interesting differences were found, as will be shown below.

The technique of testing the resistance of the young nauplii has been improved. Previously it was the practice to test the whole of each brood in one concentration of arsenite solution. It was, however, found that different broods of the same parents often had different powers of resistance. The revised testing technique was designed to overcome this difficulty. Fifteen solutions of arsenite were made in such a way that their strengths went up in geometrical progression, with the eighth just twice as strong as the first, and the fifteenth twice as strong as the eighth. These were lettered A to O, A being the weakest at a strength of N/40 and O the strongest at N/10.

Each brood is subdivided into six or eight groups, the groups being subjected to the range of testing solutions considered appropriate for them. All the broods of each set of parents are dealt with in this way and the average of their behaviour over the range of solutions employed is taken as a measure of their resistance. This method clearly reduces the inter-brood differences.

In other respects the method of testing the nauplii was the same as before.

The technical difficulties of failure of breeding, or the production of eggs in the place of nauplii, by some of the pairs, were again encountered to a rather severe extent, in spite of precautions. Hence the testing has not taken place as regularly or extensively as was hoped.

Of the lines tested C<sub>2</sub> has shown itself to have a much higher resistance than any other. In test solution N it showed practically complete survival and in test solution O, the strongest, the death rate was only 50 per cent. Stronger concentrations of arsenite are readily available in strengths fitting the chosen series by a slight modification of the testing technique, and so it will be easy to test this line in higher concentrations. The line C<sub>1</sub> had an extremely low 50 per cent. survival level (D-E) but the remaining three lines all showed this point in the region covered by test solutions F-H.

The lines C<sub>4</sub> and C<sub>5</sub> have been selected for one and two generations respectively, and, as the Table shows, in C<sub>4</sub> the resistance has not increased to a noticeable extent. There is, however, a suggestion of increased resistance following selection in C<sub>5</sub>, but the data are at present scanty, particularly for the second selected generation. The apparent effects of selection are smaller than last year's.

Now that the method of testing has been stabilised it is proposed that selection for increased resistance to sodium arsenite should be carried out in four lines, including the extremes C<sub>1</sub> and C<sub>2</sub>.

The Committee asks to be reappointed with a grant of £20.

TABLE

| Solution. |     | C <sub>1</sub><br>unselected. |                    |               | C <sub>2</sub><br>unselected. |                    |               | C <sub>3</sub><br>unselected. |                    |               |
|-----------|-----|-------------------------------|--------------------|---------------|-------------------------------|--------------------|---------------|-------------------------------|--------------------|---------------|
|           |     | Number<br>tested              | Number<br>survived | %<br>survival | Number<br>tested              | Number<br>survived | %<br>survival | Number<br>tested              | Number<br>survived | %<br>survival |
| C         | ... | 7                             | 4                  | 57            | 30                            | 30                 | 100           | 20                            | 14                 | 70            |
| D         | ... | 7                             | 5                  | 71            | 30                            | 28                 | 93            | 20                            | 13                 | 65            |
| E         | ... | 15                            | 5                  | 33            | 43                            | 42                 | 98            | 20                            | 16                 | 80            |
| F         | ... | 21                            | 5                  | 24            | 43                            | 41                 | 95            | 20                            | 7                  | 35            |
| G         | ... | 35                            | 15                 | 43            | 59                            | 55                 | 93            | 19                            | 4                  | 21            |
| H         | ... | 35                            | 3                  | 9             | 59                            | 52                 | 90            | 19                            | 5                  | 26            |
| I         | ... | 28                            | 2                  | 7             | 29                            | 29                 | 100           | 15                            | 0                  | 0             |
| J         | ... | 28                            | 3                  | 11            | 29                            | 28                 | 100           | 15                            | 0                  | 0             |
| K         | ... | 20                            | 1                  | 5             | 29                            | 27                 | 99            | —                             | —                  | —             |
| L         | ... | 9                             | 0                  | 0             | 16                            | 15                 | 94            | —                             | —                  | —             |
| M         | ... | —                             | —                  | —             | 16                            | 16                 | 100           | —                             | —                  | —             |
| N         | ... | —                             | —                  | —             | 16                            | 13                 | 81            | —                             | —                  | —             |
| O         | ... | —                             | —                  | —             | 16                            | 8                  | 50            | —                             | —                  | —             |
| Tested    |     | 205                           |                    |               | 415                           |                    |               | 148                           |                    |               |

| Solution. |     | C <sub>4</sub><br>unselected. |                    |               | C <sub>4</sub><br>selected. |                    |               |
|-----------|-----|-------------------------------|--------------------|---------------|-----------------------------|--------------------|---------------|
|           |     | Number<br>tested              | Number<br>survived | %<br>survival | Number<br>tested            | Number<br>survived | %<br>survival |
| C         | ... | 8                             | 8                  | 100           | —                           | —                  | —             |
| D         | ... | 30                            | 27                 | 90            | 68                          | 60                 | 88            |
| E         | ... | 35                            | 30                 | 86            | 68                          | 58                 | 85            |
| F         | ... | 35                            | 23                 | 66            | 227                         | 160                | 70            |
| G         | ... | 35                            | 24                 | 69            | 242                         | 148                | 61            |
| H         | ... | 35                            | 15                 | 43            | 267                         | 92                 | 34            |
| I         | ... | 35                            | 15                 | 43            | 267                         | 89                 | 33            |
| J         | ... | 17                            | 4                  | 24            | 267                         | 62                 | 23            |
| K         | ... | —                             | —                  | —             | 267                         | 57                 | 21            |
| L         | ... | —                             | —                  | —             | 160                         | 21                 | 13            |
| M         | ... | —                             | —                  | —             | 93                          | 23                 | 24            |
| N         | ... | —                             | —                  | —             | 25                          | 0                  | 0             |
| O         | ... | —                             | —                  | —             | —                           | —                  | —             |
| Tested    |     | 230                           |                    |               | 1951                        |                    |               |



| Solution. | C <sub>5</sub><br>unselected. |                    |               | C <sub>5</sub><br>selected 1st. |                    |               | C <sub>5</sub><br>selected 2nd. |                    |               |
|-----------|-------------------------------|--------------------|---------------|---------------------------------|--------------------|---------------|---------------------------------|--------------------|---------------|
|           | Number<br>tested              | Number<br>survived | %<br>survival | Number<br>tested                | Number<br>survived | %<br>survival | Number<br>tested                | Number<br>survived | %<br>survival |
| C ...     | 20                            | 17                 | 85            | —                               | —                  | —             | —                               | —                  | —             |
| D ...     | 20                            | 16                 | 80            | —                               | —                  | —             | —                               | —                  | —             |
| E ...     | 20                            | 17                 | 85            | —                               | —                  | —             | —                               | —                  | —             |
| F ...     | 20                            | 19                 | 95            | —                               | —                  | —             | —                               | —                  | —             |
| G ...     | 35                            | 17                 | 49            | 6                               | 4                  | 67            | —                               | —                  | —             |
| H ...     | 35                            | 23                 | 66            | 12                              | 5                  | 42            | 5                               | 1                  | 20            |
| I ...     | 35                            | 16                 | 46            | 12                              | 7                  | 58            | 5                               | 3                  | 60            |
| J ...     | 35                            | 13                 | 37            | 12                              | 3                  | 25            | 5                               | 1                  | 20            |
| K ...     | 25                            | 8                  | 32            | 12                              | 6                  | 50            | 5                               | 2                  | 40            |
| L ...     | 15                            | 3                  | 20            | 12                              | 2                  | 17            | 5                               | 1                  | 20            |
| M ...     | —                             | —                  | —             | 6                               | 2                  | 33            | 5                               | 1                  | 20            |
| N ...     | —                             | —                  | —             | —                               | —                  | —             | —                               | —                  | —             |
| O ...     | —                             | —                  | —             | —                               | —                  | —             | —                               | —                  | —             |
| Tested    | 260                           |                    |               | 72                              |                    |               | 30                              |                    |               |

## FRESHWATER BIOLOGICAL STATION, WINDERMERE.

*Report of Committee appointed to aid competent investigators selected by the Committee to carry out definite pieces of work at the Freshwater Biological Station, Wray Castle, Windermere* (Prof. F. E. FRITSCH, F.R.S., *Chairman*; Prof. P. A. BUXTON, *Secretary*; Miss P. M. JENKIN, Dr. C. H. O'DONOGHUE (*from Section D*); Dr. W. H. PEARSALL (*from Section K*)).

THE British Association table has been occupied by Mr. R. Misra (University of Leeds) and Dr. M. Rosenberg. The former has carried out ecological investigations on the higher aquatic plants (principally *Potamogeton*) and has studied the chemical features of the muds on which they grow. Dr. Rosenberg has continued pure culture work with a number of desmids and other algæ and has commenced investigations under natural conditions on the plankton algæ in Windermere and in the streams which feed it. It is anticipated that these investigations, if carried out throughout the year, may afford much information on the origin and causes of temporary abundance of plankton algæ and that they may be as fruitful as similar work already carried out in the sea.

## SOIL RESOURCES OF THE BRITISH EMPIRE.

*Report of Committee appointed to co-operate with the Staff of the Imperial Soil Bureau to examine the soil resources of the Empire* (Sir JOHN RUSSELL, O.B.E., F.R.S., *Chairman*; Mr. G. V. JACKS, *Secretary*; Dr. E. M. CROWTHER, Dr. W. G. OGG, Prof. G. W. ROBINSON, Prof. C. B. FAWCETT, Mr. H. KING, Mr. C. G. T. MORISON, Dr. L. D. STAMP, Mr. A. STEVENS, Dr. S. W. WOOLDRIDGE)

No meeting of the Committee has been held since September 7, 1933, during the Leicester Meeting of the British Association. At that meeting the climatic and ecological maps already prepared were exhibited, and it was agreed that they (and others to follow) should be transferred to the Imperial Bureau of Soil Science, where they could be consulted by, and if necessary forwarded to the authorities responsible for soil survey in the different countries of the British Empire. Subsequently the Bureau received rainfall maps of East Africa (Prof. L. Rodwell Jones) and of India (Mr. Williamson), and rainfall and vegetation maps of New Zealand (Mr. R. O. Buchanan). At the request of Mr. G. Milne, the soil chemist at Amani, Tanganyika, Prof. Rodwell Jones's map was sent out to him and utilised in preparing the provisional Soil Map of East Africa, a copy of which has been now deposited with the Soil Bureau. During the latter part of 1934 and 1935 the Soil Bureau was not in a position to undertake work on behalf of the Committee as it was fully engaged in preparing for the Third International Congress of Soil Science. This Congress, however, which took place at Oxford in July and August, 1935, brought together the chief soil surveyors of the British Empire and afforded an opportunity to learn their views on the Committee's project.

It was apparent that a considerable amount of soil survey work was in progress and provisional soil maps had already been published in several countries. Among the earlier maps were those of the soils and vegetation of Australia prepared by Prof. J. A. Prescott under the auspices of the Council for Scientific and Industrial Research, and the soil map of Sierra Leone by F. Martin and H. Doyne. A very tentative (geological) soil map of South Africa had been published by the South African Government, at least two tentative soil maps of India had been prepared by independent workers, and the sub-committee on Asiatic soils of the International Society of Soil Science is also correlating Indian soil data with a view to incorporating them in a map. Work on these maps was already completed, or far advanced, before the Committee was constituted. Since then, considerable progress has been made with other soil maps of British countries, and several are approaching completion. The most extensive is probably the genetic soil map of Canada prepared under the direction of Prof. A. H. Joel and later of Prof. J. H. Ellis. Mr. G. Milne's soil map of East Africa, already mentioned, introduces a new principle of cartography, and is perhaps the most extensive piece of soil mapping yet attempted in the Tropics. In New Zealand, steady progress has been made with soil survey by Mr. L. I. Grange of the Geological Department, and several detailed maps of small areas have been published. The survey, which is based primarily on geology but incorporates many features of modern American and European practice, is intended ultimately to cover the whole country. In Nigeria, the Geological and Agricultural Departments are collaborating in soil survey, but under present conditions work can only proceed slowly and



little progress has yet been made. In the West Indies and British Guiana, our knowledge of the soils, particularly from the economic standpoint, has been further enriched by the work of Prof. F. Hardy and his collaborators, though no occasion has arisen for mapping the soils. It is probable that national soil survey will become one of the chief objects of the newly formed (1935) Indian Society of Soil Science.

It will thus be seen that there are few parts of the Empire where soil survey in one form or another is not engaging the attention of the authorities. A soil survey is not, however, the object of the Committee, whose terms of reference were 'to examine and report on the soil resources of the Empire.' To fulfil this purpose, the Committee proposed to relate the external environment (especially climate and ecology) with the available soil data. Unfortunately it appeared that where one set of data (e.g. the environmental) was available, the other (soil) usually was lacking. Thus, for Canada, where a general soil map is now being prepared, the Committee has not received from its collaborators any climatic or vegetation maps. For New Zealand, on the other hand, Mr. Buchanan has prepared vegetation and rainfall maps for the Committee, but extensive soil data are lacking. Prof. I. B. Pole Evans has recently (1935) left with the Soil Bureau a copy of his new vegetation map of South Africa, but circumstances have prevented Prof. Plummer (Pretoria) from preparing a rainfall map, and practically no real soil survey work, except for irrigation purposes, has been done. Mr. Williamson has mapped the existing rainfall data for India, but the various soil maps are admittedly largely hypothetical and there is little agreement as to which approximates most closely to truth. Australia, on the other hand, has a rainfall map prepared for the Committee by Prof. Rishbeth and soil and vegetation maps previously prepared by Prof. Prescott. No data have been collected by the Committee for the colonies and dependencies, except East Africa (Prof. Rodwell Jones). It must be admitted that East Africa is the only instance in which the Committee has been able to make useful contact with the 'man-on-the-spot' (see above).

The man-on-the-spot is, indeed, both the essential link and the greatest difficulty in the Committee's project. His co-operation is imperative, as he alone can verify soil descriptions and data. But he is usually, if not overworked, at least involved in so many different problems that he is unable to give attention to matters outside his ordinary duties. If he is engaged on soil survey, his methods are likely to be prescribed not so much by standard scientific principles as by the economic requirements and agricultural policy of his country. There is no likelihood at present of securing any uniformity of outlook or execution in soil surveys. At the same time it seems probable that at least provisional soil maps of most countries in the Empire will be available within the next decade. In view of these facts, the Committee might consider the advisability of continuing to compile its geographical data independently of the actual soil surveyors, aiming at being in a position, as and when soil surveys are published, to utilise the latter in conjunction with the geographical data to produce on a more or less uniform basis something analogous to a *land* classification survey. In this connection it may be mentioned that the International Society of Soil Science proposes that land classification, as opposed to soil classification, should be one of the chief subjects for discussion at its next international congress in 1940. The Committee might explore the possibilities of producing, for presentation to this congress, a scheme and examples of land classification in the British Empire based on the material it has collected.

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## CHRONOLOGY OF THE WORLD CRISIS.

*Report of Committee on Chronology of the World Crisis* (Prof. J. H. JONES, *Chairman* ; Dr. P. FORD, *Secretary* ; Prof. G. C. ALLEN, Mr. H. M. HALLSWORTH, C.B.E., Mr. R. F. HARROD, Mr. A. RADFORD, Prof. J. G. SMITH).

(1) It was resolved (a) that a comprehensive survey be made of the economic position of Great Britain, as shown by evidence of a general character, and that a sub-committee be appointed to be responsible for the preliminary draft ; (b) that further chapters be prepared for the following groups of industries, the persons named to be invited to undertake responsibility for the work.

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|--|---|
| 1. Agriculture . . . . .                   | Messrs. C. S. Orwin, A. W. Ashby.   |
| 2. Fuel, Power and Chemicals . . . . .     | Prof. J. H. Jones and colleagues.   |
| 3. Metals and Shipbuilding . . . . .       | Messrs. McCallum, E. Allen.   |
| 4. Transport, including shipping . . . . . | Mr. Hallsworth, Dr. K. G. Fene-<br>lon.                                   |
| 5. Textiles . . . . .                      | Messrs. Jewkes, A. N. Shimmin,<br>and Prof. Daniels to be con-<br>sulted. |
| 6. Finance . . . . .                       | Prof. J. G. Smith.  |
| 7. Distribution . . . . .                  | Dr. P. Ford.  |

Persons responsible for 1, 2, 3, 4, 6, and 7 have accepted.

(2) The members of the sub-committee to be responsible for the preliminary draft : Prof. Jones, *Chairman* ; Profs. J. G. Smith, G. C. Allen, Mr. H. M. Hallsworth. Dr. Fay to be asked to serve if he wishes. Prof. Jones to make the first draft and to circulate.

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## KENT'S CAVERN.

*Report of Committee appointed to co-operate with the Torquay Antiquarian Society in investigating Kent's Cavern* (Sir A. KEITH, F.R.S., *Chairman* ; Prof. J. L. MYRES, O.B.E., F.B.A., *Secretary* ; Mr. M. C. BURKITT, Dr. R. V. FAVELL, Miss D. A. E. GARROD, Mr. A. D. LACAILLE).

THE following report has been received from the excavators :

' This season, between October 28, 1935, and May 11, 1936, thirty-three days have been occupied in digging out the central part of the " Vestibule " of Kent's Cavern, thus continuing work commenced in 1932. A depth of 21 ft. 6 ins. below the original stalagmitic floor has been arrived at, and it is hoped that exploration will proceed from that point next season, for there still appears plenty of cave earth mixed with limestone fragments, in which artifacts and other interesting finds are likely to be discovered. From the fairly even distribution of teeth and bones it is evident that the introduction of cave earth was slow, for otherwise probably they would have been found massed together, if they had been subjected to frequent inrushes of water.

' As lower levels are being reached, so the quantity of specimens seems to

diminish, but it is encouraging to note that each find obtained lower down becomes of greater value, as each foot down suggests a more remote period.

'A great quantity of rock and loose fallen stone has had to be removed, and as these cover more than three-quarters of the area at the bottom of the excavation, the work of removal, and sorting, is necessarily rather slow.

'Fallen blocks are so numerous and compact that the possibility of great subversion of contents of the cavern is ruled out, but crevices may have existed through which a flint could slip down to a lower level than one would expect to find it, in the same way that complete bones are sometimes found which must have fallen between rocks, and have escaped the attentions of the hyena.

'Flints were not numerous this season, but fortunately there were more Mousterian than Aurignacian, some of the former being fine specimens, and new forms for Kent's Cavern.

'The usual cave fauna has been found in fair abundance. Messrs. Powe, the proprietors of the cavern, have recently much improved the lighting conditions throughout, which incidentally has made exploration work more efficient and agreeable.

'FREDERICK BEYNON, ARTHUR H. OGILVIE.'

The Committee asks to be reappointed, with a further grant.

## EARLY MINING SITES IN WALES

*Report of Committee appointed to investigate early mining sites in Wales* (Mr. H. J. E. PEAKE, *Chairman*; Mr. OLIVER DAVIES, *Secretary*; Prof. V. GORDON CHILDE, Dr. C. H. DESCH, F.R.S., Mr. E. ESTYN EVANS, Prof. H. J. FLEURE, F.R.S., Prof. C. DARYLL FORDE, Sir CYRIL FOX, Dr. F. J. NORTH, Mr. V. E. NASH WILLIAMS).

THE majority of the mines in Wales suspected of being exploited anciently have been visited with a view to more detailed examination next year. In some cases, such as Halkyn Mt., recent work has completely destroyed traces of earlier periods, but in most a few remains can be found, while some of the ancient mines of central Wales have been little disturbed.

Apart from the Roman state-mines at Dolaucothly, which fall into a different category, there appears to be a fairly unified group of early workings in north and central Wales. These seem normally to have sought copper ore, even in districts where lead abounds. They cannot at present be dated, but they are characterised by the use of stone hammers for pounding, while the rock was probably broken by fire-setting. The hammers, which may still be picked up in large numbers, are selected pebbles from beach or stream-bed, usually rather long so that they could be grasped safely, as notably at Cwm Ystwyth; rarely they are provided with a rough rill for the attachment of a handle, like one found at Nantyreira and several in Chester Museum from Alderley Edge. The relation of these shapeless rilled stones to those with finely polished groove in several of the North Wales museums is at present uncertain.

The early workings can stylistically be distinguished from their successors. In North Wales Roman influence was strong, so the use of an adit guided by a shaft at Llandudno or a pick-cut shaft at Talargoch need not surprise. The mining area of central Wales was opened up by the road from Wroxeter to Caersws and Aberystwyth, but was hardly affected by Roman civilisation.

In this part the mines were restarted in the early sixteenth century, but little developed until the reigns of Elizabeth and her successors. The German advisory engineers of that time had a developed mining technique; at some of the early mines, such as Cwmsymlog and Gwestyn, there are rows of pits 3-5 yds. apart, like those in Central Europe. Hammer-stones were not employed (though the large crushing and sorting dumps on the top of Halkyn Mt. cannot yet have used mechanical power), the rounded glacial pebbles found on tips show no marks of use. The tips themselves are large and well defined. The vein-outcrops were attacked by wide horizontal opencasts, and adits were driven for drainage and haulage from the bottoms of the valleys. The exploitation was by superposed levels 20-30 ft. apart (Stockwerkbau). It is probable that the stoping out of the lodes was mainly in an upward rather than a downward direction.

The stone-hammer people grubbed out their veins with small opencasts, which they worked downwards to water-level. These workings have no drainage; they are usually 20-30 yds. long, as at Nantyricket Nantyrarian and Ogof Widdon, 4-10 ft. wide according to the width of the vein, and stop almost perpendicularly at each end, seldom continuing underground with galleries. Haulage was therefore to the surface with a rope, and not horizontally with a hand-car, probably a German invention of which a specimen is said to have been found at Rhiw-rugos. If propping was once used it has disappeared, and the removal or fall of the breccia has caused the walls of the working to stand firm. Such work is obviously primitive. The discovery of ore-bodies was haphazard; the workings are always situated where there was little detritus or boulder-clay, but save at Nantyreira seem not to have been revealed in stream-beds, which were perhaps overgrown. Normally one vein out of many, often a subsidiary as at Nantyricket, was discovered; the ancients had no geological sense to seek for others or for its continuation.

Another form of ancient working, known at Llanymynach Newtown and in Monmouthshire, is an irregular cave following a small outcrop on the hillside; from this there branch off small winding galleries, which grubbed out all ore within reach.

It has not yet been possible to discover ancient smelting-places. Those reported at Trefeglwys appear to be bloomeries, perhaps of the seventeenth century, but information has been received about others near Bow Street and Yspytty Ystwyth. It is particularly important to find slag-heaps, and excavation at them should yield valuable information about primitive furnaces. They must usually have been situated in the woodland near the mines, though smelting was sometimes carried out also on settlements such as Rhostryfan, Din Llugwy, etc. The slag is probably covered by humus, but any information regarding it would be especially welcomed.

In central Wales the distribution of hilltop and promontory camps in the mining area is striking. These seldom, however, contain evidence of metallurgy, and it may be doubted whether there is any necessary connection between them and the mines. Detailed work with distribution maps will be carried out later.

The committee asks for a grant for next year to carry out excavations and analyses of metal objects believed to be derived from Welsh mines.

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## BLOOD GROUPS.

*Report of Committee on the Blood Grouping of Primitive Peoples* (Prof. H. J. FLEURE, F.R.S., *Chairman*; Prof. R. RUGGLES GATES, F.R.S., *Secretary*; Dr. J. H. HUTTON, C.I.E., Mr. R. U. SAYCE).

DURING the past year progress has been made in blood grouping various primitive peoples, especially in Canada, India, Tibet and Kenya. Serum for testing the Eskimos was sent to a Canadian Government expedition two years ago, and from a radio message recently received at Ottawa it appears that 185 Eskimos belonging to several tribes west of Hudson Bay, including the Caribou Eskimos, show a very high percentage of B. This unexpected result can only be interpreted when the full data are received. In September 1935, 98 Micmac children were tested in an Indian school at Shubenacadie, Nova Scotia, and Prof. Ralph P. Smith has recently tested 100 Micmacs, chiefly adults, at the Whycocomagh Reserve in Cape Breton Island and 67 at the Barra Head Reservation. These three sets of tests appear to be comparable and a full account will be published later. Arrangements have also been made for blood grouping the Ojibway and Iroquois Indians at various reservations in Ontario and Quebec.

In Kenya serum has been sent to Dr. J. W. Vint of Nairobi, who is typing various native tribes, but the results are not yet complete.

A short paper on Tibetans has been published (*Man*, p. 147, 1936) giving the results of testing 187 natives chiefly of Gyantse. The results, 14.9 per cent. O, 47.1 per cent. A, 13.9 per cent. B, 24.1 per cent. AB, are of extraordinary interest as they show a higher percentage of AB combined with a lower percentage of O than almost any other racial group. This is especially significant when contrasted with the American Indians, which the Tibetans resemble in some respects.

In India Mr. A. Aiyappan has carried out tests of the pre-Dravidian Paniyans of Wynaard, which show 20 per cent. O, 62.4 per cent. A, 7.6 per cent. B, 10 per cent. AB. The very high percentage of A is in marked contrast to the Hindoos and confirms the relationship of these pre-Dravidian people to the Australian aborigines. A short account of this work is in the press for *Man*. Sera for all the Indian work have kindly been donated by the Haffkine Institute of Bombay, whose sera were first tested with samples sent from England and found to be the same. Dr. Eileen W. Macfarlane has tested various groups in Cochin, South India, including Dravidians, pre-Dravidians, Syrian Christians and the so-called White Jews and Black Jews. These tests are being combined with anthropometric measurements, which will add much to their value. A full report is being prepared, and a preliminary note had been published (*Current Science*, vol. 4, p. 653, 1936). The White Jews of Cochin number scarcely a hundred. The fifty adults typed gave 18 per cent. O, 62 per cent. A, 20 per cent. B. The Black Jews number about 800, of which 106 were tested, giving 73.6 per cent. O, 10.4 per cent. A, 16 per cent. B. In such small communities inbreeding probably has an important effect in producing aberrant blood group percentages.

In the Naga Hills, Assam, blood grouping tests are being made by Dr. C. Vieyra and Dr. S. S. Kundu, and the results are being correlated with racial and language studies by the Deputy Commissioner, Mr. J. P. Mills. At Srinagar, Kashmir, Dr. James Flower has taken up blood grouping tests in addition to anthropometric measurements on the peoples in this region.

## DERBYSHIRE CAVES.

*Fourteenth Interim Report of Committee appointed to co-operate with a Committee of the Royal Anthropological Institute in the exploration of Caves in the Derbyshire District* (Mr. M. C. BURKITT, *Chairman*; Dr. R. V. FAVELL, *Secretary*; Mr. A. LESLIE ARMSTRONG, Prof. H. J. FLEURE, F.R.S., Miss D. A. E. GARROD, Dr. J. WILFRID JACKSON, Prof. L. S. PALMER, Mr. H. J. E. PEAKE).

*Creswell Crags*.—Mr. Leslie Armstrong, F.S.A., reports as follows :

*Pin Hole Cave*.—When my last report was presented a section of the lower deposits of the cave left undisturbed in the 1873 excavations was in course of examination. This was situated between the entrance door and the point 23 ft. distant at which my excavations commenced in 1924, and of this length 13 ft. had been dealt with. This work has been continued and the whole remaining portion of the deposit systematically examined, thereby finally completing the excavation of this cave from the entrance door to the position beyond the main chamber, where the Committee decided work should cease and the type section of the whole series of the deposits be preserved in situ.

As stated in the 1935 report, the Mousterian (1) and (2) occupation levels were found to be intact and undisturbed by the earlier excavations. Between 10 ft. and 13 ft. indications were observed of the Mousterian (3) level also, slightly disturbed superficially at first but diminishing in degree; from 13 ft. to 23 ft. it proved to be entirely undisturbed and was covered to an average depth of 12 ins. by a remnant of the upper cave earth. Traces of occupation by man and animals became more abundant as the excavation advanced and included a small hearth in the Mousterian (2) level, with remains of charcoal and wood ash and remnants of split animal bones around it, some of which show traces of burning. A quartzite implement, a stone pounder and split quartzite pebbles were found on the same horizon. The Mousterian (1) level yielded the largest flint flake found in the cave during the whole course of the excavations. Judged by type and technique this artifact might be classified as Clactonian. It exhibits the characteristic oblique striking platform and pronounced bulb of the Clacton culture and bears evidence of use, but, in view of the fact that only one small flake at all comparable has been found previously, it probably represents a chance product of the normal Mousterian industry of the Pin Hole, or an importation.

The remnant of upper cave earth overlying the Mousterian (3) level and of Upper Aurignacian Age, yielded several artifacts of flint, including a typical angle burin and a long blade. No additions were made to the fauna already recorded. The work was completed on June 6 last, thus bringing the excavations which have been proceeding systematically and regularly in this cave since September 1924 to a final conclusion.

I am gratified to be able to report that the Pin Hole Cave and Mother Grundy's Parlour have now been scheduled by H.M. Office of Works as Ancient Monuments, in accordance with the recommendation of the Committee, supported by the Council of the Association at the Norwich Meeting: also that the Keeper of the Department of British and Medieval Antiquities at the British Museum has offered to provide facilities during the coming autumn for a special exhibition at the Museum of the whole of the objects discovered during the course of these excavations.



'*Boat House Cave*.—Work is now in progress here and the material overlying the relic bed is in course of removal. This averages 6 ft. in thickness, two-thirds of which is stiff red clay, introduced as puddling when the embankment of the adjoining lake was formed and which occupies the whole of the front and extends to the rear of the visible portion of the cave. At the time of writing, the position of the relic bed has been defined over a small area, but no attempt will be made to excavate this until the whole of the "dead" covering has been removed over a large portion of the cave floor.

'A grant of £25 is earnestly requested for the continuation of this new work.'

## SUMERIAN COPPER.

*Seventh Interim Report of Committee appointed to report on the probable sources of the supply of Copper used by the Sumerians* (Mr. H. J. E. PEAKE, *Chairman*; Dr. C. H. DESCH, F.R.S., *Secretary*; Prof. H. BALFOUR, F.R.S., Mr. L. H. DUDLEY BUXTON, Prof. V. GORDON CHILDE, Mr. O. DAVIES, Prof. H. J. FLEURE, F.R.S., Sir FLINDERS PETRIE, F.R.S., Dr. A. RAISTRICK, Dr. R. H. RASTALL).

### (REPORT BY THE SECRETARY.)

FURTHER analyses on behalf of the Committee have been carried out in the Metallurgy Department of the National Physical Laboratory. The specimens received during the past year have included an important series from Troy, and other specimens from N. Syria, Palestine, and Egypt. Micro-chemical methods have again been used, when only small quantities of material have been available. As in previous years occasional specimens of iron, gold and lead have been examined as well as the copper and bronze with which the Committee is mainly concerned.

The specimens from Troy were received from Prof. C. W. Blegen, and represented all levels except Troy IV.

Specimens 1 and 2 were so much mixed with earthy matter that the original composition could not be calculated, and the proportion of arsenic found is certainly higher than in the unoxidised copper. The remainder were either uncorroded or corroded so uniformly that the analyses could be safely recalculated to 100 per cent.

|             |        |   | Copper | Tin   | Arsenic | Nickel | Lead |
|-------------|--------|---|--------|-------|---------|--------|------|
| 1 Troy      | I      | . | 14.94  | —     | 1.98    | 0.04   | —    |
| 2 "         | I      | . | 36.00  | —     | 2.20    | 0.09   | —    |
| 3 "         | II     | . | 98.8   | —     | 1.1     | 0.11   | —    |
| 4 "         | II     | . | 98.7   | —     | 1.1     | 0.18   | —    |
| 5 "         | II     | . | 96.7   | 2.18  | 0.97    | 0.11   | —    |
| 13 "        | III    | . | 95.0   | 2.9   | 1.5     | 0.11   | 0.47 |
| 14 "        | III    | . | 97.6   | —     | 2.3     | 0.03   | —    |
| 6 "         | V      | . | 90.4   | 9.6   | —       | —      | —    |
| 7 "         | VI     | . | 91.9   | 8.0   | —       | 0.05   | —    |
| 15 "        | VI     | . | 99.9   | trace | trace   | —      | —    |
| 16 probably | VI     | . | 87.7   | 12.1  | 0.21    | —      | —    |
| 8 Troy      | VI-VII | . | 87.3   | 11.5  | 1.2     | —      | —    |
| 9 "         | VII    | . | 91.0   | 9.0   | —       | —      | —    |
| 10 "        | VII    | . | 91.2   | 8.2   | 0.55    | —      | —    |



The compositions thus fall into two groups, indicating distinct sources for the copper in the earlier and later periods. Objects from the earlier levels, I-III, are of copper containing a relatively large proportion of arsenic and some nickel, three only containing a little tin. Objects from the higher levels, V-VII are mainly true bronzes, with little or no arsenic and no nickel, but include one specimen of pure copper.

Only a single object from Ur was received from the British Museum, this being fragments of a bronze vessel labelled ' Kassite period.' The analysis gave :

|                   |                |
|-------------------|----------------|
| Copper . . . . .  | 92·5 per cent. |
| Tin . . . . .     | 7·17 „ „       |
| Arsenic . . . . . | 0·20 „ „       |
| Nickel . . . . .  | 0·13 „ „       |

Mr. Mallowan sent a copper bead from Chagar Bazar in N. Syria, found in association with Tell Halaf pottery, and stated to be the oldest piece of copper yet found in Syria. It was completely corroded, but gave 63·31 per cent. of copper and 8·71 per cent. of sand with a little iron (possibly derived from the soil) but without any trace of arsenic, tin, nickel or sulphur. It is thus an exceptionally pure specimen of ancient copper, the deficiency from 100 per cent. representing oxygen and carbon dioxide only.

Specimens from Tell Ajjul in Palestine were received from Sir Flinders Petrie. The copper objects gave the following results :

|                  | Copper | Tin | Arsenic | Nickel | Iron |
|------------------|--------|-----|---------|--------|------|
| Adze, unnumbered | 93·80  | —   | 2·17    | 0·03   | 1·51 |
| „ 750 . . .      | 97·57  | —   | 0·86    | 0·03   | 0·19 |
| Pin . . . . .    | 92·23  | —   | 1·68    | 0·03   | —    |
| Coil of Wire . . | 91·20  | —   | 0·88    | 0·19   | 0·27 |

A lead rod, numbered 954, gave

|       |        |       |
|-------|--------|-------|
| Lead  | Copper | Iron  |
| 97·63 | 0·26   | trace |

and a bar of solder was found to contain

|       |          |       |        |         |       |
|-------|----------|-------|--------|---------|-------|
| Lead  | Antimony | Tin   | Copper | Bismuth | Iron  |
| 38·87 | 3·05     | 57·74 | 0·23   | trace   | trace |

One more dagger was examined from Mr. Starkey's finds at Tell Duweir, supplementing the analyses given in the last report. The analysis showed 98·5 per cent. of copper and 1·2 per cent. of iron with a trace of sulphur, but no tin, arsenic or nickel.

Mr. A. Lucas sent three miniature tools from the tomb of Tutankhamen, and a copper ribbon of the XII Dynasty. All these specimens were quite free from corrosion.

|                  | Copper | Tin   | Arsenic | Nickel | Iron | Sulphur |
|------------------|--------|-------|---------|--------|------|---------|
| Model Adze       | 98·4   | trace | trace   | 0·3    | 0·5  | —       |
| „ Hoe            | 97·6   | 1·3   | trace   | 0·2    | 0·3  | trace   |
| „ Yoke           | 96·8   | 1·8   | trace   | 0·3    | 0·1  | 0·3     |
| Ribbon . . . . . | 97·7   | —     | 1·48    | 0·03   | 0·15 | 0·1     |

Mr. Lucas also submitted several samples of gold. It had been stated, from an old analysis by Gladstone, that gold from the II Dynasty of Egypt contained tellurium, and might therefore have come from the Carpathian region. The specimens now received were fragments of gold foil covering a coffin of 6-ply wood from the step-pyramid of Zoser at Saqqara, and of

gold rivets used to attach the foil. The fragments were examined spectrographically and proved to be free from any trace of tellurium. Silver and copper were present in considerable proportions with, rather unexpectedly, an appreciable quantity of tin, especially in the rivets, with traces of iron, lead and antimony. A Transylvanian origin is therefore ruled out. A specimen of gold quartz from the Eastern desert showed silver with traces of iron, and lead and copper, but no tin, antimony, or tellurium.

Mr. Lucas also sent a sample of copper ore from the ancient Abu Seyal mine in the Eastern desert, which proved to consist mainly of oxide of iron, but with 5·48 per cent. of copper and 0·33 per cent. of nickel, and a piece of malachite from a tomb, probably pre-dynastic. This contained 34·30 per cent. of copper, 0·67 per cent. of iron, and, unexpectedly, 2·41 per cent. of zinc, with much sand and insoluble matter.

It has not been possible to obtain further samples of copper or tin ores from sources likely to have been used by the early metallurgists. Two slags from ancient copper-smelting sites on the Iranian side of the Baluchistan frontier were sent by Dr. J. V. Harrison. They proved to be typical ferrous silicate slags, containing 0·66 and 0·74 per cent. of copper oxide respectively, with no tin, arsenic or nickel.

In view of the interest attaching to the early smelting of iron, every opportunity of examining fragments of corroded iron has been taken. Mr. Lucas sent a minute fragment of a thin blade of iron, inserted into a small silver amulet in the form of a sphinx's head, now in the Cairo Museum, No. J. 47314. It is of the XI Dynasty, and was found by Mr. H. E. Winlock at Deir el Bahri. A micro-analysis showed that iron and nickel were present in the ratio of about 1 : 10. The iron is therefore undoubtedly meteoritic.

On the other hand, two fragments of oxidised iron found by Mr. Mallowan at Chagar Bazar, dated by the pottery as not later than 2700 and perhaps as early as 3000 B.C., proved to be entirely free from nickel, and must be of terrestrial origin. Manganese was absent.

The numerous analyses of objects from Thermi made for the Committee have now been published in full.<sup>1</sup>

Too late for inclusion in this report, a further series of specimens from Troy has been received from Prof. Blegen and others from Mr. Mackay's excavations at a new site in Sind.

The work of the Committee having become known, the Secretary is frequently asked by excavators and by museum curators to undertake analyses of objects of archæological interest. The recent Reports have contained analyses of objects only indirectly connected with the Sumerian problem, and the special technique which has been developed proves to be of value in the solution of archæological problems. It is evident, however, that the small grant from the British Association will not allow of extensive work in this field. With the co-operation of the Department of Scientific and Industrial Research, the scope of the investigation could be widened. It is suggested that an organisation might with advantage be set up, having as its object the analytical and metallographic examination of objects connected with the early use of metals, and the comparison of their composition with that of available ores. A sum of £100 a year would provide for a considerable number of analyses, and could perhaps be provided by a committee representing the interests of excavators, museums, and archæological societies.

<sup>1</sup> *Excavations at Thermi in Lesbos.* By Miss Winifred Lamb. (Camb. Univ. Press.)

## ROUTINE MANUAL FACTOR.

*Report of the Committee appointed to develop tests of the routine manual factor in mechanical ability.* (Dr. C. S. MYERS, C.B.E., F.R.S., *Chairman*; Dr. G. H. MILES, *Secretary*; Prof. C. BURT, Dr. F. M. EARLE, Dr. LL. WYNN JONES, Prof. T. H. PEAR.)

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## I. RÉSUMÉ OF WORK CARRIED OUT DURING PREVIOUS YEARS.

A. *On the Nature and Measurement of Manual Skill.*

THE results of extensive research into the nature of the factors involved in assembling work have been summarised in previous reports of the Committee. Among the more important conclusions were: (i) that assembling work divides broadly into (a) 'mechanical' assembling work, and (b) 'routine' assembling work; and (ii) that 'mechanical' assembling work involves a mechanical group-factor, together with specific manual factors, whereas in 'routine' assembling work the mechanical factor is replaced by a manual group-factor of fairly wide range.

Attempts to measure the manual group-factor led to the devising of four new manual tests, viz. (i) the pin board—a board 12 in. square in which are inserted 84 brass pins over which the subject is required to wind string in a prescribed way; (ii) the pin-stick—a 12-in. length of wood, of  $\frac{3}{4}$  in. square section, in which are inserted 40 brass pins around which the subject is required to wind string with one hand while rotating the stick with the other; (iii) the eye-board—a board 15 in. square containing 90 eyes and 20 clips, in which the subject is required to thread laces through the eyes and then clip them under the clips; and (iv) a test in which the subject, using the same board, alternately threads the lace through a bead and then an eye.

Inter-correlations of these tests and the original routine assembling operations indicated the presence of the same manual group-factor in these tests as was formerly observed in the routine assembling operations. Statistical analysis of the inter-correlations showed the eye-board to be the most highly saturated of the tests (0.80) and it was therefore decided to



determine the norms for this test with various age groups and for different types of subject.

The need for exploring other aspects of manual skill, as expressed in many industrial operations which are not of the assembling type, has also been stressed in previous reports of this committee.

#### *B. On the Nature and Measurement of Mechanical Aptitude.*

Alongside the above described work on routine assembling went an extensive investigation into the factors involved in mechanical assembling. The mechanical factor found in these operations was demonstrated to be the same as that previously discovered by Dr. Cox in his original mechanical aptitude tests. There were, in addition, various specific factors, but the *manual* activities involved in these operations were found to have little in common with the manual group-factor in the routine operations.

In view of the range and importance of the mechanical factor it was decided to determine norms for the mechanical aptitude tests for various age groups.

It was also decided to explore further aspects of mechanical ability by (i) devising tests suitable for younger children, and (ii) investigating the nature of the factors in other kinds of mechanical work.

### II. WORK CARRIED OUT DURING THE CURRENT YEAR.

#### *A. The Further Analysis and Development of Manual Tests.*

1. *Application of Test in a Factory.*—The manual tests referred to above were administered as individual tests, the score being the time taken to do a given quantity of work. The eye-board test has now been modified to permit of its use as a group test, the score being the number of eyes threaded in a given time. In this form it was given to 66 factory workers engaged in various kinds of assembly work. At the same time the testees were assessed for ability at (a) fine assembling work, and (b) coarse assembling work, by a foreman well acquainted with their work. The correlation between the test and each of these assessments indicated a fairly close correspondence between the test and coarse assembling (0.75) and a much lower correlation with fine assembling (0.30). A careful inquiry was subsequently made into the nature of the operations which had been classified as 'coarse' and 'fine'; whence it transpired that the 'coarse' was mainly concerned with fitting or screwing pieces together, or inserting screws into holes, whereas the 'fine' assembling work consisted of winding various coils of wire. It was thus seen that this test selects well for those kinds of operations (assembling the electric lamp holder) upon which it was based, but that further tests are needed where operations of the coil-winding type are concerned.

The need for further research into other kinds of manual work is thus again exemplified in the results of this investigation, for this distinction between 'fine' and 'coarse' assembling is evidently a real one. The latter, under the name of routine assembling, has already received much attention in our previous reports, whereas the former calls for closer study than it has hitherto received.

The experiment suggested in our last report, in which it was proposed to compare ability at routine assembling operations with ability at tests involving larger muscular movements, was begun at a Central School at Edmonton. Owing to lack of financial support, however, this work has been considerably delayed. It is hoped to continue the experiment next year.

2. *Improvement in the Eye-board Test.*—After considerable enquiry and correspondence, a firm has been found who are prepared to make clips of the necessary size and shape from spring steel, at a reasonable cost, if required in sufficient quantities. Clips made from this material are more durable and require less supervision than the older kind of clip, and so enhance the practical value of the test.

3. *Norms of Performance.*—The work of establishing norms of performance at the eye-board manual test has continued. Percentile scores for half-yearly age-groups are available for the various groups described in our last report, and for the above-mentioned group of factory workers.

#### B. *The Further Analysis and Development of Mechanical Tests.*

1. *Improvements in certain of the Tests.*—With a view to rendering the administration of these tests easier and more uniform, new selective versions of the tests have been devised together with a special form of chart on which the testee records the responses. This method of administration makes the task of scoring entirely automatic and easy, and has been applied to tests of the 'Models,' 'Diagrams' and 'Mechanical Explanation' type (cf. *Mechanical Aptitude*, Methuen & Co.).

2. *Norms of Performance.*—The work of determining norms for various groups at various ages has continued during the current session. The selective version of the Models Test (M<sub>1</sub>) has been given to 242 secondary school boys, aged 14–17 years and the calculation of percentile scores for each age group is nearly completed.

The selective versions of the Models Test (M<sub>1</sub>), Diagrams Test (D), and Mechanical Explanation Test (E) have also been given during the past year to 145 boys aged 13+ seeking entry to Technical Schools and the percentile scores for this group are now available, in addition to those for Secondary, Technical and University students referred to in our last report.

### III. THE FURTHER ANALYSIS OF MECHANICAL TESTS.

With a view to extending the application of mechanical tests to a wider age-range, two new tests of the 'Models' type were drawn up and given to two groups of elementary school boys aged 10–14 years. To bring out any differences that might be caused by the introduction of the selective method, the tests were given in both the selective and the inventive forms. In addition to these, tests of general intelligence and two new paper-folding tests were also given. The scoring of the mechanical and general intelligence tests has been completed and that of the paper-folding tests is in progress. It is hoped to continue the work of analysis next session.

A programme of work directed towards the further investigation of factors in types of 'mechanical' work not hitherto explored has been drawn up, but owing to lack of financial support it has not been possible to start this yet.

### IV. CORRESPONDENCE AND DISSEMINATION OF INFORMATION.

As the result of inquiries arising out of this Committee's work, which have been received from persons interested in the application of manual and mechanical tests for educational and vocational guidance, a fair amount of correspondence (including two meetings with investigators in Birmingham) describing the tests and results so far achieved has been undertaken during the current year. The reprint of an article entitled 'The Bearing of Recent Researches into the Nature of Mechanical Aptitude and of Manual



Skill on the Problem of School Organisation ' has been sent to interested persons.

#### V. PROPOSED FURTHER WORK.

The need for exploring other aspects of manual skill and of mechanical aptitude has been indicated above. The difference there observed between 'coarse' and 'fine' assembling afford but one illustration of the practical value and urgency of such work. Although a good deal of ground has been covered by the work supported by this Committee, there remain many industrial operations, both 'manual' and 'mechanical,' about which our psychological knowledge is meagre and unsystematised. Work in these directions has already been started, as indicated above. As progress is made in the discovery of the special abilities involved in these activities, so, it is hoped, tests for their measurement in individuals may be developed and standardised.

#### VI. RENEWAL OF GRANT.

In order that this work may be carried out, and the work already in progress may be allowed to continue, it is requested that the grant be renewed. In view of the fact that the grant allocated by the Association for last year's work was not paid owing to an oversight regarding the date of application, and funds which have hitherto partly supported this work are now exhausted, it is hoped that the grant may be substantially increased.

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### PERSEVERATION.

*Interim Report of Committee on the nature of perseveration and its testing*  
(Prof. F. AVELING, *Chairman*; Dr. WM. STEPHENSON, *Secretary*;  
Dr. M. COLLINS, Dr. P. E. VERNON, Prof. J. DREVER).

THE Committee, confining itself for the present to cognitive processes, notes that the items of activity, concepts, or descriptive processes listed below have been variously described as perseverations, or perseveration, and recommend that for the present the word perseveration should be given a wide connotation, being best regarded as a classificatory term embracing the items so listed. It is in no way claimed that these items are exclusively defined; and the list is put forward without prejudice to other items which may be added to it later.

- (1) *Perseverative Tendency* (Muller and Pilzecker).
- (2) *General inertia* (Spearman).  
(Distinguishable from the clearness variation of 'attention' by its apparent independency of will or effort.)
- (3) *Secondary function* (O. Gross).
- (4) *Motor Interference*.  
(A thoroughly habituated activity is considered, because of its after-effect, to interfere with another closely resembling it.)
- (5) *Perseverations*.  
(The apparently free and spontaneous recurrence of ideas, thoughts, tunes, etc.)
- (6) *Psychiatric perseveration*.  
(The abnormally persistent repetition of a word, or words, etc., or motor action, in spite of attempts by the observer to stay the



repetition and in spite of desire by the subject not to persevere. It is to be distinguished from stereotypy and motor automatisms by the relative independency of the latter upon fatigue.)

- (7) Disability in switching the mind from one topic of thought or mode of work to another.

The Committee observes that experimental work has already been directed towards determining the extent, if any, to which these various activities or processes obey any general laws, and notably whether individual differences with respect to them vary in proportion to one another in populations of normal, and abnormal, persons. It suggests that further experimental work should be directed along these same lines.

The Committee notes that although large numbers of tests have been described, there are apparently wide differences in the precise methods used in scoring and in applying them. With the object of making results more directly comparable, and as a guide to others who may wish to work on problems connected with perseveration, the Committee puts forward the following recommendations :

#### A. Foreword.

In many *p*-tests two essential parts are involved, (i) an initial activity not critically effected by perseveration, (ii) a subsequent activity in which perseverative effects are expected to be critical. The score in (i) is represented usually as X, and the activity as X-activity, while those for (ii) are designated Y and Y-activity, respectively.

*In so far as it is hoped to examine purely cognitive processes*, the quality of the work done by subjects should be similar in X- and Y-activities, except for any changes occurring in Y-activity due to perseverative influences, and every attempt should be made to ensure that temperamental or other incidental influences do not enter critically into Y-activity (relative to X), so confusing the matter at issue. It is not doubted that temperamental or other influences of a non-cognitive kind may enter critically into Y-activity, and that these are worth investigating, but for the present purpose they are matters for control. It is probable that different techniques could be used for the same tests, were it intended to examine such influences and not the purely cognitive ones under consideration. The Committee, for this reason, have incorporated several recommendations in the testing procedures described below, directed towards the above objective.

#### B. Classification of *p*-Tests.

The following classification of tests is convenient for descriptive purposes, and points to certain considerations of theoretical interest :—

- (1) Tests involving alternation of a thoroughly habituated and well-established activity with a new one closely resembling it.  
(Examples : The SS-writing test (Bernstein) ; the hh-writing test (Wolters) ; the ee, ZZ, ww, 99, 55, 66, 22, aa and similar tests (Stephenson).)
- (2) Tests involving breaking away from a thoroughly habituated and well-established activity, but without alternation.  
(Examples : Mirror image test (Jones) ; Saying Colours (Stephenson) ; IT test (Jones).)
- (3) Tests involving alternation, but between more or less equally old-established, or between non-habituated, activities.  
(Examples : Adding and Subtracting (Bernstein) ; Brackets ({} Wolters) ; Writing arb2c3 . . . . (Pinard).)

- (4) Tests involving 'carry over' from X-part to Y-part.  
(Examples : Cancellation (Bernstein) : Increase Induction (Stephenson).)

### C. General Instructions.

Where it is possible, the following instructions may be given, or the following directions followed :—

- (i) Use  $\frac{1}{4}$ -in. squared paper, with instructions that each symbol should fill one square.
- (ii) Give clear instructions as to the sequence in which reverse or mirror-wise symbols have to be written, and emphasise that all such symbols have to be written in that, and no other, way.
- (iii) Give pauses to allay local muscular fatigue.
- (iv) Give instructions that as many symbols as possible have to be written in the given time, but with good quality, which must be maintained throughout.
- (v) Allow a short fore-practice trial, so that instructions will become familiar, and so that the fair trials can proceed with a minimum of disturbance from beginning to end.

### D. Standard Times for Tests of Class I.

Using the SS-writing test as an example, the testing might proceed as follows :—

- (i) Fore-practice trial :

|            |             |    |            |
|------------|-------------|----|------------|
| a. Writing | S S S S S S | .. | 30 seconds |
| b. „       | 2 2 2 2 2 2 | .. | 30 „       |
| c. „       | S 2 S 2 S 2 | .. | 30 „       |

(As much time as necessary is spent in giving instructions prior to a, b and c.)

- (ii) Fair Trial :

|            |             |    |             |
|------------|-------------|----|-------------|
| a. Writing | S S S S S S | .. | 30 seconds. |
| b. „       | 2 2 2 2 2 2 | .. | 30 „        |
| c. „       | S S S S S S | .. | 30 „        |
| d. „       | 2 2 2 2 2 2 | .. | 30 „        |
| e. „       | S S S S S S | .. | 30 „        |
| f. „       | 2 2 2 2 2 2 | .. | 30 „        |
| g. „       | S 2 S 2 S 2 | .. | 90 „        |

(Allow 10 seconds pause between a-b, b-c, c-d, e-f, and f-g, and 20 seconds between d-e. Directions for subsequent activity are given during this pause.)

Two such fair trials are recommended.

### E. Scoring for Tests of Class I.

- (i) Some attempt should usually be made to apply suitable and consistent corrections, where necessary, to the writing in (g), if it differs markedly in quality or size from that in parts (a) to (f).
- (ii) Scores a, b, c . . . g are the numbers of correctly and adequately written symbols in the respective parts. Corrections made by the subject to symbols in part (g) are counted as errors, even though the final correction may have resulted in a correctly formed symbol.

- (iii) It often happens that perseverative or other disturbances enter into parts (b), (d), (f), destroying any orderly sequence of output in these activities. Where any one or two of these activities is grossly affected, as shown by the fact that their outputs are small compared with the others of the same kind, only the activity with greatest output should be used for purposes of X-score, the output being increased two-fold or pro rata, so as to bring it up to what might have been expected for a total of 90 seconds writing.
- (iv)  $X\text{-score} = a + b + c + d + e + f$   
 $Y\text{-score} = 2g$
- (v) For research purposes  $p$ -score is taken to be  $p = (X - kY)$ .  
 (Where  $k$  is a value such that  $r_{X(X - kY)} = 0$ ).
- (vi) X, Y, and  $p$ -scores should be placed on record.
- (vii) Where a test is applied twice, as suggested above,  $p$ -score is calculated for each separately.

#### F. *Standard Times for Tests of Class II.*

(All tests of Class I can be used, the part (g) being omitted for scoring purposes. Whereas in the scoring procedure, correction is made for any inherent difficulty in parts (b), (d) and (f) of Class I, no such correction is possible in tests of Class II.)

(Times as in Class I for tests of that class.)

|                 |               |    |     |          |
|-----------------|---------------|----|-----|----------|
| Fore-practice : | X-activity    | .. | 30  | seconds. |
|                 | Y-activity    | .. | 30  | „        |
| Fair Trial :    | a. X-activity | .. | 60  | „        |
|                 | b. X-activity | .. | 60  | „        |
|                 | c. Y-activity | .. | 120 | „        |

(Give twice.)

(Make pauses as for Class I.)

(Score as in Class I, for  $X = a + b$   
 $Y = c$ )

#### G. *Times, etc., for Classes III and IV.*

The directions, etc., for Classes III and IV are the same as those, respectively, for Classes I and II.

The Committee recommend that tests should be tried, following the above procedure, and reported upon in due course.

It is hoped to issue a full report in September, 1937.

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### SOCIAL PSYCHOLOGY.

*Report of Committee to consider definite lines of research in Social Psychology*  
 (Prof. J. DREVER, *Chairman*; Mr. R. J. BARTLETT, *Secretary*; Prof. F. AVELING, Prof. F. C. BARTLETT, F.R.S., Prof. C. BURT, Dr. MARY COLLINS, Mr. ERIC FARMER, Miss E. J. LINDGREN, Dr. C. S. MYERS, C.B.E., F.R.S., Prof. T. H. PEAR, Dr. R. H. THOULESS, Mr. A. W. WOLTERS).

WITHIN the wide field of Social Psychology the Committee, without claiming to give an exhaustive classification, would select as in pressing need for solution problems that fall into the following four groups :



I. Problems involving, and dependent upon, the distribution in the community of sensory, motor, and intellectual capacities.

II. Problems of temperament and character, involving the exploration of the possibility of developing satisfactory tests for temperament and character traits, and applying these tests under standard conditions.

III. Problems involved in the study of the factors and influences determining failure on the part of individuals—children or adults—to adjust themselves satisfactorily to the conditions of social life.

IV. Complex and important problems in the border country lying between psychology and sociology on the one hand, and psychology and anthropology on the other, and in many cases involving economics in addition.

In the investigation of the problems of Group I it will be necessary to test representative samples of the population with sensory, motor, sensori-motor, intelligence, and mechanical ability tests. The samples should be taken from different social, economic, and geographical environments, and should comprise, if possible, not only children, but the children's parents. The results of such testing should be examined with the object of discovering :

- (a) The manner in which the qualities measured by the respective tests are distributed throughout the population.
- (b) How far parents and children resemble one another.
- (c) To what extent any differences are traceable to known environmental influences or to more remote hereditary influences.
- (d) To what extent different social or occupational groupings tend to develop qualities known to be important for industrial proficiency.
- (e) What part the qualities measured by the tests play in industrial proficiency in the various occupations taken up by the children, or in which the parents are engaged.
- (f) How far present methods of selecting elementary school children for technical or higher education are effective in selecting those best qualified to benefit from such education.

In the investigation of problems of Group II it will be necessary :

- (a) To study present methods of estimating personality—in particular the interview—with the object of ascertaining the reliability of the results obtained.
- (b) To develop tests for emotional, temperamental, and volitional characteristics.
- (c) To determine the reliability of such tests.
- (d) To investigate the part played by emotional and temperamental characteristics in adjustment to the conditions of occupational life.

In the investigation of problems of Group III it is desirable to study :

- (a) To what extent maladjustment in children or adults is due mainly to psychological characteristics or to environmental causes.
- (b) How far such maladjustment can be rectified or its effects diminished by change of environment or other possible action.

Moreover, 'maladjustment' ought to be understood widely, and its study ought to include the study not only of temporary maladjustment resulting from sudden changes, as from school to work, from work to retirement, and the like, but also of the maladjustment frequently found in the case of the adopted child, the illegitimate child, and the step-child, and of the still wider maladjustment resulting from institutional education, or from environmental or other conditions affecting adult social groups.

The problems belonging to Group IV fall into several sub-groups, such as :

- (a) Problems involved in the interrelations of social groups, national, economic, religious, etc.
- (b) Problems involved in the social influences of changes in economic conditions, environmental factors, and the like, and conversely the economic influences of social changes bringing about changes of outlook, attitude or interests.
- (c) Problems of socially determined motives and incentives.

Problems belonging to this Group are exceedingly complex, and their study in any adequate way by the psychologist has hitherto been largely neglected, although in some cases a good deal of work has been done by anthropologists. A large part must necessarily be played by field-work and observational methods. An immediate problem would seem, therefore, to be the devising and refining of a technique which will yield reliable results and the training of investigators.

These investigations can only be undertaken through the co-operation of a large number of workers. It is desirable that there should be a representative Committee charged with the task of co-ordinating the work of the different investigators, so far as this is possible, so that isolated pieces of work may be brought into touch with the main body of research.

This Committee would, therefore, make the following recommendations :

1. That the Council of the British Association for the Advancement of Science set up the necessary co-ordinating Committee.
2. That the functions of this Committee be, on the one hand, to make and maintain contact with the various bodies or individuals carrying on investigations in the different fields, and, on the other hand, to take such steps as may be possible to stimulate and encourage investigation.
3. That this Committee include representatives of Anthropology, Economics, Education and Psychology, and possibly Physiology and Zoology.
4. That this Committee report at regular intervals to the General Committee and that its reports be printed.

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## TRANSPLANT EXPERIMENTS.

*Report of Committee on Transplant Experiments* (Sir ARTHUR HILL, K.C.M.G., F.R.S., *Chairman*; Dr. W. B. TURRILL, *Secretary*; Prof. F. W. OLIVER, F.R.S., Prof. E. J. SALISBURY, F.R.S., Prof. A. G. TANSLEY, F.R.S.).

THE experiments are being continued along the lines laid down by the British Ecological Society. A fourth biennial report, bringing the details of the experiments up to date to December 31, 1935, has been prepared and has been accepted for publication in the *Journal of Ecology*, February 1937.

It is requested that the above Committee be kept in being for another year and that £5 be granted towards the cost of continuing the experiments.

# SECTIONAL TRANSACTIONS.

## SECTION A.

### MATHEMATICAL AND PHYSICAL SCIENCES.

Thursday, September 10.

DISCUSSION ON *The evolution of the Solar System* (10.0).

Sir JAMES JEANS, F.R.S.—*The evolution of the Solar System.*

Hypotheses as to the origin of the Solar System may be classified according to the number of stars which were concerned in the birth of the planets. Pre-eminent in the category of solitary-star theories is the Nebular Hypothesis of Laplace, which is now out of favour because it fails to satisfy certain numerical tests. To the category in which two stars are involved belong the Planetesimal Hypothesis of Chamberlin and Moulton, various forms of tidal theory, and the collision theory of Bickerton which has been recently rejuvenated by Jeffreys. In the three-star category comes the recent theory of Lyttleton, according to which the planets resulted from an encounter between a single star and a binary.

These various theories can be checked and tested by the general principles of dynamics, particularly that of 'conservation of angular momentum,' as also by certain principles of an even more general kind.

Prof. ARTHUR HOLMES.—*Geological time and former glaciations in relation to the evolution of the Solar System.*

The work of Paneth on the helium-ratios of iron meteorites suggests an age of the order 2,800 million years for the solar system. Of the rocks of the earth's crust the oldest so far recognised have been found in South Dakota (Black Hills) and Manitoba (east of Lake Winnipeg). The downward sequences, with ages determined by the lead-ratio method, are as follows :

#### BLACK HILLS, SOUTH DAKOTA.

Harney Peak Granite ( $1,500 \pm 40$  million years).

(?) LEAD SYSTEM.

Game Lodge Granite ( $1,820 \pm 70$  million years).

ESTES SYSTEM: Quartzite and conglomerate with iron-formation, slate and green schist.

#### SOUTH-EAST MANITOBA.

Peridotite — Appinite — Granite — Pegmatite Intrusions ( $1,750$  million years).

RICE LAKE SYSTEM :

*Wanipigow phase* : Quartzite, greywacke, arkose, slate.

*Beresford Lake phase* : mainly volcanic.



*Unconformity.*

NEMO SYSTEM: Quartzite, greywacke, arkosic conglomerate, iron formation.

*Manigotagan phase*: Quartzite, conglomerate, greywacke, slate.

*Base not exposed.*

Granite and granodiorite (pebbles in Manigotagan conglomerates).

*Base not exposed.*

Granite (source of Nemo arkose, etc.).

From these records it may be inferred (*a*) that the age of the earth is not less than 1,900 to 2,000 million years, and (*b*) that the conditions of temperature and rainfall controlling the weathering responsible for the raw materials of these oldest sediments probably fell within the range of present-day climatic conditions. A further indication that there has been no secular variation of climates during geological time is provided by the distribution in time of former ice-ages:

| Million<br>Years. |  |
|-------------------|--|
| 0-1               | <i>Pleistocene.</i>  |
| 200               | <i>Permo-Carboniferous.</i> —South America; South and Central Africa; India; Australia.                                    |
| 500               | <i>Eo-Cambrian.</i> —Spitzbergen; Greenland; Scandinavia; South Australia. (?) Yangtse, China.                             |
| 600-700           | <i>Transvaal-Nama-Katanga.</i> —S.W. Africa; Angola; Congo; Rhodesia; Transvaal. (?) Simla, India. (?) Broken Hill, N.S.W. |
| 800-900           | <i>Huronian.</i> —Cobalt, Ontario. (?) Witwatersrand, Transvaal.   |
| 1000-1100         | <i>Bothnian.</i> —Finland.   |
| (?) > 1100        | <i>Damara.</i> Chuos district, S.W. Africa.  |
| (?) > 1650        | (Unnamed).—Medicine Bow Mountains, Wyoming.  |

The characteristics of the Pre-Cambrian varved clays so closely resemble those of the Pleistocene as to leave no doubt that they were formed under seasonal variations as marked as those of to-day. In the older examples, as in other ancient sediments, iron is largely ferrous, indicating an atmosphere poor in, or free from, oxygen.

Geological evidence indicates that for nearly 2,000 million years there have been no astronomically significant changes in the thermal and dynamical relations between the earth and the sun. There is a hint of large-scale periodicity in the recurrence of terrestrial glaciation (though the data, as yet, are far from complete), and this may point to a corresponding periodicity in the fluctuations of solar radiation.

Prof. E. A. MILNE, F.R.S.—*The evolution of the Solar System: dynamical aspects.*

In recent papers the author has derived the forms of the laws of dynamics and of gravitation from purely kinematic considerations based on the analysis of the description of motion in terms of the individual observer's awareness of a temporal experience. The laws thus derived differ in a significant way from the usual empirical formulations of these laws, more especially in the occurrence in them of the kinematic time-variable  $t$ . It is now possible to show that these rationally derived laws pass over into the exact form of the local empirical Newtonian formulations on transforming from kinematic time  $t$  to dynamical time  $\tau$ , where  $\tau = t_0 \log(t/t_0) + t_0$ , where  $t_0$  is the present value of  $t$  obtained from the expansion of the universe.

A position-vector  $P$  measured by light-signals using the kinematic time-scale is equivalent to a position-vector  $\Pi$  measured on the dynamic time-scale, where  $P = \Pi(t/t_0)$ . A problem first formulated explicitly by de Sitter is thus solved, and his conjectural solution verified, by the process of the identification of inductive laws of nature with laws reached deductively. Reckoned on the kinematic time-scale, the age of the solar system is a small multiple of  $10^9$  years. But reckoned by dynamical events, such as the number of swings of a macroscopic pendulum, the number of rotations of the earth or the number of revolutions of a planet, the age is infinite. The 'short' and the 'long' time-scales are thus in principle reconciled by fundamental reasoning.

Prof. W. H. McCREA.—*R. A. Lyttleton's binary star hypothesis concerning the origin of the Solar System.*

GENERAL DISCUSSION ON *The evolution of the Solar System.*

Dr. H. JEFFREYS, F.R.S.—*A summing up of the discussion on the evolution of the Solar System.*

Dr. W. BOWIE.—*The importance of isostasy in earth studies* (12.20).

During the past few decades isostasy has advanced from a purely theoretical concept to a very practical phase of earth sciences. By means of geodetic data the ideas advanced in the last century by Pratt, Airy, Dutton and others have been proved to be an actual physical characteristic of the earth. While we cannot now say that isostasy has been proved beyond question for the entire earth's crust, yet for those areas in which there are abundant geodetic data and where the isostatic investigations have been made, it has been found that, in its general aspects at least, the crust of the earth is quite in conformity with the idea of isostasy.

The isostatic reductions that have been made for deflection-of-the-vertical and gravity stations give us a measure of the degree to which isostasy exists. Necessarily in making the isostatic reductions of the geodetic data, a set of very simple assumptions had to be made. The closeness with which the theoretical and observed geodetic data can be brought into agreement is the measure of the degree to which isostasy exists according to the assumptions made.

It is believed by many that the so-called isostatic anomalies for the deflection-of-the-vertical and gravity stations do not necessarily represent a deviation of a large section of the earth's crust from normal mass. These anomalies are due rather to a heterogeneous distribution of mass in the outer portions of the earth's crust. It is this concept that is employed by geophysicists and others in searching for buried geological structure that has significance in locating ores, petroleum, natural gas and salt. It is only when, for extensive areas, the gravity and deflection stations are very close together, that one is justified in making any definite assumption as to the dimensions of a block of the earth's crust that may be considered in equilibrium independently of other portions of the crust.

With isostasy proved, at least in its general aspects, we have a new starting-point for geological research designed to unfold the history of the geological past and to discover the forces and processes that have been involved in changes in the elevation of the earth's surface and the horizontal shifting of rock. It is becoming evident to students of the earth that there must be a wide application of physical and chemical methods in geological research.

## Friday, September 11.

PRESIDENTIAL ADDRESS by Prof. A. FERGUSON on *Trends in modern physics* (10.0).

In the course of the address the President remarked that, through the kindness of Imperial Chemical Industries, Ltd., he had been able, in collaboration with his colleague, Mr. Cockett, to obtain preliminary estimates of the specific heat of heavy water at different temperatures. These values were obtained by experiments made on a sample of 375 gm. of heavy water of 99.2 per cent. purity, lent by Imperial Chemical Industries, Ltd. The results, which are expressed in terms of the 20° calorie, are shown in the table given below. It will be seen that the specific heat is consistently higher than that of ordinary water, and that a minimum is indicated at about 41° C. The results for ordinary water were obtained by the same method as that used in the experiments on heavy water.

TABLE.

| Temp. ° C. | H <sub>2</sub> O | D <sub>2</sub> O   |
|------------|------------------|--------------------|
| 15         | 1.0010           | 1.009 <sub>0</sub> |
| 20         | 1.0000           | 1.007 <sub>0</sub> |
| 25         | 0.9991           | 1.005 <sub>4</sub> |
| 30         | 0.9986           | 1.004 <sub>3</sub> |
| 35         | 0.9984           | 1.003 <sub>6</sub> |
| 40         | 0.9984           | 1.003 <sub>0</sub> |
| 45         | 0.9986           | 1.003 <sub>3</sub> |

DISCUSSION on *Elastic and absorptive properties of fibres* (11.10).

Dr. W. ASTBURY.—*Elastic protein fibres.*

Certain natural protein fibres, in particular the hairs of mammals, are endowed with long-range elastic properties recalling those of rubber. The effect is shown by X-ray and related studies to be due to combinations of polypeptide chain-molecules which are normally in a regularly folded configuration, from which they may be pulled out straight by the application of tension, and to which they return when the tension is released. By suitable modification of the state of cross-linkage of these polypeptide chains both the elastic range and the driving force of elastic recovery may be varied considerably. Animal hairs, for instance, may actually be contracted to a length only half their natural length. The chief muscle protein, *myosin*, both from the X-ray and physical elastic point of view, is closely analogous to one of the forms of the hair protein, *keratin*, and there is apparently some fundamental type of molecular fold common to both. The crystalline proteins, which are built from 'globular' molecules, have now also been shown to be based on folded polypeptide chains. The latter are liberated from their special configuration by the change known as 'denaturation,' the resulting insoluble mass being often highly elastic like keratin and myosin. X-rays show that this elasticity is again to be referred to groups of folded polypeptides which may be drawn out into straight chains just as keratin and myosin may be so drawn out. By this means artificial protein fibres may be prepared from originally globular molecules.

The detailed interpretation of the deformation of folded protein chains and their long-range elasticity presents one of the most difficult and fascinating problems in molecular mechanics.



Dr. M. MATHIEU.—*The X-ray cinematography of a simple fibre reaction.*

Cellulose fibres are transformed into trinitro-cellulose when exposed to gaseous nitrogen pentoxide at ordinary temperature. By using an X-ray tube with rotating anticathode it is possible to take diffraction photographs of such fibres every two minutes or so, since an exposure of one minute is sufficient for each photograph, and so to follow easily the evolution of the new structure.

The regularity of the original structure first gradually disappears in the direction of the fibre-axis, until a stage is reached when there remain only equatorial reflections and the pseudo-period corresponding to the length (5.2 Å.) of a glucose residue. The molecular chains then move further apart and slide over one another so as to leave the effective residue thickness unaltered, whereupon the (101) reflection of nitro-cellulose appears. After this, little by little, the molecular chains fold and take up their stable configuration, and the fibre period of 25.1 Å., which characterises trinitro-cellulose, can be observed.

The whole process is completed in an hour and serves as a simple and striking example of how physical and chemical transformations can now be followed in detail with the aid of a powerful X-ray tube.

Dr. J. SPEAKMAN.—*Some chemical aspects of the elastic properties of the keratins.*

The keratins consist of parallel peptide chains bridged by cystine and salt linkages, and the configuration adopted by the structure under any circumstances represents a balance between the tendency of the peptide chains to fold into six-membered rings and the resistance to folding offered by the side linkages. The reactivity of these side linkages depends on their state of strain, which, in turn, depends on the configuration of the structure. In consequence, the properties of each type of linkage in keratin influence those of the remainder. For example, the reactivity of the cystine linkage in strained fibres is frequently at a maximum under conditions where the salt linkages are most stable. Similarly, the elastic properties of chemically modified fibres present many features of unusual interest.

Dr. E. GRIFFITHS, F.R.S., and Mr. J. H. AWBERY.—*Apparatus for maintaining constant humidity.*

The need for maintaining constant humidity is experienced in many industrial processes, such as paper making, textile spinning and weaving, as well as in the laboratory.

Two forms of apparatus suitable for laboratory work have been devised, one for supplying a stream of air at constant humidity, and the other for maintaining the atmosphere in a chamber at a fixed humidity.

In both forms, the result is attained by mixing dry and moist (nearly saturated) air in suitable proportions. This method has many advantages over the methods in which salts or solutions are used to attain the desired humidity directly.

In the apparatus for providing a stream of air at known humidity, air is drawn through the apparatus, and branches into two streams, each provided with a flowmeter. One stream passes through water towers, and the other over silica gel. The streams are then reunited, a dew-point hygrometer being inserted in the combined stream.

The advantage of the type of controlled chamber now described is that

the streams of air are not running continuously, and thus the desiccating agent is conserved for long periods. A strip of gold-beater's skin in the chamber itself (which is provided with a fan for stirring the air) carries electrical contacts which complete circuits when the length of the strip deviates in either direction from the desired length. The circuit which is completed when the gold-beater's skin becomes too short, operates a fan driving a stream of moist air into the chamber; similarly the other circuit drives dried air into the chamber.

#### AFTERNOON.

Visit to Stonyhurst College and Observatory.

### Monday, September 14.

DISCUSSION on *The production and technical applications of high voltages* (10.0).

Dr. T. E. ALLIBONE.—*The production and application of high voltages.*

The paper reviews the many types of generators at present in use in engineering and physical laboratories for the production of high alternating, direct and impulse voltages, with special reference to the purpose for which each generator is constructed.

In electrical engineering such generators are used for the testing of insulation, and details of the A.C. and impulse voltage tests on insulating material and on assembled apparatus are given. In the physical laboratory such generators are used for the most part to produce swift moving electrically charged particles such as electrons or positive ions for the generation of X-rays or neutrons or for investigations on atomic structure. Details of the apparatus most commonly used for these purposes are given.

Dr. G. W. C. KAYE, O.B.E., and Mr. W. BINKS.—*The ionisation measurement of short-wave radiation.*

The success and safety of cancer treatment by X-rays and radium, whether singly or combined, largely depend upon the accurate measurement of the quantity or 'dose' of radiation administered. The most satisfactory method available is a physical one involving the determination of the ionisation produced in air by the electrons liberated by the radiation. For X-radiation the air-ionisation unit of quantity called the röntgen has been accepted internationally, but the difficulties hitherto encountered in measuring very short-wave radiation, such as the  $\gamma$ -rays from radium, have given rise to doubts concerning the feasibility of expressing X-ray and radium measurements in a common unit, a procedure admittedly desirable. The difficulties of realising the röntgen in the case of  $\gamma$ -rays are due to the long ranges of the electrons liberated in air (up to 10 or 12 ft.). The authors show that these difficulties can be overcome by the use of a very large parallel-plate ionisation chamber, of effective dimensions about 12 ft. by 10 ft. By this means the unification of X-ray and radium dosage measurements has been effected. Such a chamber, while serving its purpose as an ultimate standard of reference, is of course quite impracticable for medical purposes. The present results, however, establish the fact that for everyday practice small ionisation chambers having appropriately thick walls of 'air-equivalent' material—a type already in use for X-ray measurements—can be successfully employed for  $\gamma$ -rays.



Prof. W. M. THORNTON.—*Measurement of voltage by spark gaps.*

- (1) The sphere gap as a voltmeter. Order of accuracy attainable. Differences of calibration, causes of differences. Ions in gap, spread of field, corona on high tension system, oscillations on applied wave as affecting peak value. Formulæ proposed. Sphere gap must be regarded as an empirical voltage indicator and not as a substandard.
- (2) Sparking in uniform fields between parallel plates with rolled edges. This can be regarded as a standard voltmeter. It is fundamental, consistent and accurate to more than 1 in 1,000 at all voltages. A limiting gap for each diameter. This gap has no spread of field, random ionisation in a much larger volume of air, irregularities are eliminated. It is not affected by strong fields and can be used without shielding.
- (3) *Method of calibration.*—Ellipsoid voltmeter found to be more reliable standard. Capacitance divider method used as an additional check. Order of accuracy obtained is individually 1 in 10,000 and is entirely consistent.
- (4) Voltages of order of 100–200 kv. can now be measured to the same degree of accuracy as the ampere and standard cell.
- (5) *Measurement of impulse voltages.*—The sphere gap has a serious time-lag, which may give more to an impulse ratio of 6. (See Allibone, *J.I.E.E.*) Theoretically the parallel plates have a negligible time-lag,  $10^{-8}$  sec.

Mr. R. DAVIS.—*The breakdown of dielectrics under transient electrical stresses.*

The experimental study of the breakdown of gaseous, liquid, and solid dielectrics has been greatly aided by the development of the impulse generator, and the high speed cathode ray oscillograph. With high voltages some form of voltage divider for use in conjunction with the oscillograph is required, and the precautions to be taken in using the resistor type are discussed. Errors in recording are introduced chiefly through the capacitance to earth of the high voltage arm of the divider.

The breakdown of air is considered with reference to different electrode systems, including the special case of a solid dielectric located between the electrodes in parallel with the air path. Examples of the former are sphere gaps, and of the latter, the insulators used in high voltage transmission systems. Experimental laws are discussed, and the generalisation made, that breakdown occurs most easily when the stress at the positive electrode is greatest. The implications of this are considered in relation to polarity effects in measuring gaps and flash-over of insulator systems. Reference is made to the impulse strength of liquid and solid dielectrics, and, in the case of the latter, to the part played by the immersing medium.

Dr. S. WHITEHEAD.—*Some aspects of the electric strength of dielectrics.*

The general principles on which depend the ability of a gas to remain an insulator under the application of a high voltage or electric stress are known, but solid dielectrics present a more complex problem. Although the immediate and best-known difficulties are those arising from heterogeneous composition and structure, it is interesting to consider the ultimate limitations which would apply even to a uniform dielectric. Firstly, there is the liability of a dielectric to thermal instability which can be assessed by the magnitude of the maximum voltage which can be applied, so as to produce



a uniform (electrical and thermal) field, however great the thickness. This voltage might be regarded as a constant of the material. Secondly, the conception of ionisation and the possible existence of statistical 'ionisation potentials' is considered in analogy with ionisation in gases. Thirdly, the determination of the field strength which causes electrical failure of the structure is examined from the theoretical and practical aspect. It is indicated that in general these limitations do not, of themselves, restrict unduly the voltages and stresses applied in practice and that a considerable increase in the severity of present working conditions would be possible without involving these ultimate limits.

Mr. C. W. MARSHALL.—*Some electrical discharge phenomena on high voltage systems.*

Discharge phenomena encountered in operating high voltage transmission systems may be classified as follows :

- (a) Corona.
- (b) Surface discharges on porcelain.
- (c) Internal discharges in solid insulation.
- (d) Arc discharges.

(a) *Corona*.—Corona or brush discharge takes the form of a steady violet-coloured discharge in the vicinity of the high voltage conductor. The discharge current is very small, of the order of microamperes. Corona usually occurs on outdoor high voltage plant and transmission lines. It is due to the local breakdown of the air owing to high voltage gradient, and is intensified by humid weather conditions.

Slide 1 : Corona discharge on 132 kv. insulators.

(b) *Surface discharges on porcelain*.—Surface discharges often take place on the porcelain insulators of overhead lines and outdoor plant. These discharges are of the nature of intermittent spark discharges ; they are audible and visible. The discharge current is of the order of tens of milliamperes. Such discharge phenomena are due to polluted and humid atmospheric conditions.

Slide 2 : Surface discharges on insulators in fog.

Slide 2a : Oscillogram of discharge current.

(c) *Internal discharges in solid insulation*.—Internal discharges occur in voids in solid insulation, e.g. cable dielectric. The air is ionised owing to its low dielectric constant and to the high stress (up to 16 kv./mm.) at which the dielectric is worked. These discharges give rise to an increase in the power factor of the insulation, and this fact is utilised to detect them.

Slide 3 : Cable end showing discharge tracking.

(d) *Arc discharges*.—Arc discharges or flashovers involve currents of the order of 1,000 amperes which persist until the supply is cut off. Any of the types of discharge mentioned may develop into arc discharges involving complete breakdown of the insulation. Arc discharges are often produced by lightning. The high voltage lightning discharge initiates an arc which is sustained by the power supply.

Slide 4 : Arc discharge on 132 kv. line.

GENERAL DISCUSSION ON *The production and technical applications of high voltages.*

Dr. J. A. V. FAIRBROTHER.—*A new method for investigating conduction phenomena in semi-conductors* (12.5).

Using a tungsten wire coated with a layer of insulating material, a method is described whereby Langmuir probe methods of measurement in a low-pressure mercury discharge can be made to yield information on the electrical behaviour of the insulating material.

For pure aluminium oxide the electrical conductivity is found to vary with temperature in accordance with A. H. Wilson's theory of electronic semi-conductors. The Wilson energy difference  $W_2 - W_1$  is found to be 2.9 electron volts between 1280° K. and 1725° K. and 6.6 electron volts at higher temperatures. The critical temperature 1725° K. is approximately the sintering point of alumina.

Experimental evidence is given in support of the discovery of electron diffusion through alumina. Mention is made of the bearing of this phenomenon on the experiments of Reimann, Treloar and E. F. Lowry, relating to the thermionic emission from oxide coated cathodes.

The conduction currents flowing across an alumina layer 0.005 in. thick between tungsten and plasma in the forward and reverse direction are given at different temperatures for voltages up to 250 volts. At high temperatures the conductivity is greater in the direction of electron flow from metal to oxide to plasma.

#### AFTERNOON.

Excursion to works of Metropolitan Vickers Electrical Co., Ltd., Trafford Park, Manchester.

### Tuesday, September 15.

Dr. L. VEGARD.—*Changes of intensity distribution within the auroral spectrum due to sunlight and other causes* (10.0).

The spectrum of the auroral luminescence is mainly composed of the following parts :—

- (a) The green auroral line ( $\lambda = 5577$ ).
- (b) The red lines 6300, 6365, of which the first predominates.
- (c) The first negative group of nitrogen.
- (d) The first positive group of nitrogen.
- (e) The second positive group of nitrogen.

The observed effects of intensity variations may be conveniently classified as follows :—

- (1) Change of intensity distribution with altitude. In 1923 the writer found an increase in the ratio  $c$  to  $a$  with increase of altitude.
- (2) Type effects. It has, e.g., been found that the ratios  $a/d$  and  $a/c$  are smaller for certain diffuse areas than for the ordinary distinct radiant forms.
- (3) Intensity variations for the same type—usually accompanied by colour changes. The red aurora of type A was found to be due to an enormous enhancement of the line  $b$  relative to the other parts, and type B was due to enhancement of red bands of the first positive group.
- (4) Recently it has been found by the writer in collaboration with E. Tønsberg that in a sunlit atmosphere the auroral spectrum shows

pronounced enhancement of  $b$  and/or  $d$  relative to  $a$ , and probably also a slight increase. The increase of  $c/a$  responsible for red auroræ of type A was explained by the writer as due to presence of ozone, and this is supported by the observed effect of sunlight on this same ratio, because we may expect that the ozone concentration is greatest on the day-side of the earth.

#### DISCUSSION on *Low temperature physics* (10.20).

Dr. H. GRAYSON SMITH.—*Saturation currents in supraconductors* (10.20).

In a continuation of the experiments which have been performed at Toronto on the supraconductivity of thin films of tin, it has been definitely shown that there is an upper limit to the current in the supraconducting state, apart from the effect of the magnetic field caused by the current.

It has recently been found that: (1) For films of sufficient thickness their normal transition points were unaffected. The current strength at which resistance reappeared was considerably less than that required to cause the critical magnetic field at the surface. (2) Penetration of an external magnetic field through a film commenced with a field strength somewhat less than half the threshold value.

The experiments seem to be in qualitative agreement with the theory of F. and H. London concerning the electromagnetic behaviour of supraconductors. They indicate that the surface layer in which the supra-current flows is considerably deeper than hitherto supposed, namely  $\sim 10^{-1}$  cm.

Dr. K. MENDELSSOHN.—*Normal and anomalous supraconductors* (10.35).

Two kinds of supraconductors can be distinguished in respect to their thermal and magnetic behaviour:

(1) 'Normal' behaviour is shown by some very pure metals (e.g. Sn, Pb, Hg, Tl) with undistorted crystal lattice. These substances show a reversible change to zero induction at the threshold curve, and the difference of free energy between the supraconductive and the non-supraconductive state can be deduced from the threshold values by simple thermodynamic equations. The transition between the two states and the conditions under which equilibrium can be reached has been investigated in detail on samples of varying purity, crystal size and geometrical shape.

(2) Supraconductive alloys do not show a reversible change to zero induction, and the penetration of a magnetic field does not coincide with the destruction of supraconductivity. Experiments on the thermal behaviour (specific heat, heat of transition, magneto-caloric effect) of these 'anomalous' supraconductors show that the simple thermodynamical treatment cannot be applied in their case. The question arises whether this 'anomalous' behaviour is solely due to secondary effects like inhomogeneity of the sample or whether it must be ascribed to an essential difference in the constitution of the supraconductive state.

In order to explain the behaviour of the 'anomalous' supraconductors phenomenologically we have compared them with a magnetic 'sponge', the skeleton of which consists of regions of very high threshold value. Experiments are described by which this hypothesis has been tested and which allow us to trace the intermediate stages between 'normal' and 'anomalous' supraconductors.



Mr. J. G. DAUNT.—*Experiments on the thermal and magnetic behaviour of superconductors* (11.0).

In continuation of the work of Mendelssohn and Moore on the magnetocaloric cooling obtained with superconductors, a method is described of reaching very low temperatures by the adiabatic magnetisation of superconductors. The advantages of the method are the comparatively low magnetic fields required and the fact that the cooling substance is a metal, to and from which heat can easily be transported by the free electrons. In the experiments the working substance was a sphere of very pure polycrystalline tin, which was found to fulfil the necessary requirement of reversibility in the transition between the normal and superconductive states. The suitability of various substances and alloys for the working substance is discussed with regard to their thermal and magnetic properties.

It was also determined that the threshold curve of tin is not a parabola. Further experiments confirm the non-parabolic form of the threshold curve of lead and mercury. A brief description of the method of measuring the threshold curves is given.

Dr. B. ROLLIN.—*Properties of liquid helium* (11.15).

An account is given of the properties of helium in the condensed state. Because of the large value of the zero point energy in relation to the lattice energy, the behaviour of liquid helium is in many respects remarkable. This seems to be the explanation of the impossibility of solidifying liquid helium merely by reducing the temperature.

The transformation which occurs in liquid helium at the  $\lambda$  point ( $2.2^\circ$  K.) is especially interesting. At this point there is a large change in the entropy of the liquid, so that below this point the liquid has only a very small entropy and is therefore in a highly ordered state. As would be expected, the physical behaviour of this ordered liquid phase is remarkable. It has been found to have an extremely small viscosity and a very large thermal conductivity. The high thermal conductivity is not only of theoretical interest but of practical importance, especially in the attainment of thermal isolation of vessels containing liquid helium.

An outline is given of further researches to be made in connection with condensed helium.

Dr. A. H. COOKE.—*The magnetic method of cooling* (11.30).

The principle of the magnetic method of cooling paramagnetic salts, by which the lowest temperatures are at present attained, is explained, and an account is given of the procedure developed in the Clarendon Laboratory, Oxford, for experiments at temperatures down to  $0.01^\circ$  K. A survey is made of the phenomena to be investigated in this region, and of the use of the procedure for the measurement of very small energy changes.

The possibility of reaching still lower temperatures by making use first of the electronic magnetic moments and then of the nuclear moments of substances is discussed. On considering the rates of attainment of thermal equilibrium within the paramagnetic salts, and between the salts and other substances, it is found that only in metals can the nuclear moments be employed for such a process.

Mr. G. L. PICKARD.—*The expansion method for liquefying helium* (11.45).

The principle of the Simon expansion method of liquefying helium (or hydrogen) is explained and a typical apparatus and working procedure are

described. The results are given of a series of experiments made to determine the yield of liquid helium obtained from different initial conditions of pressure and temperature; in addition some measurements on the equation of state and the specific heat of gaseous helium in so far as they affect the expansion method are reported.

#### GENERAL DISCUSSION on *Low temperature physics*.

Dr. J. HARTMANN.—*The Acoustic Jet Generator* (12.15).

The acoustic air-jet generator, introduced to the members of the British Association at the Oxford Meeting, 1926, has since then been made the subject of investigations as to its *modus operandi*, its performance, its techniques of measurement, etc. It now represents, undoubtedly, the most effective means available for the production of large power high frequency waves in air, and would seem to open up a wide field of scientific and technical applications. The communication deals mainly with the explanation of the peculiar phenomenon underlying the working manner of the generator. This phenomenon and the air vibrations produced in the apparatus are illustrated through a number of photographs taken by means of the method of striæ and by a special method developed jointly with the generator (the method of the Riemann mirror).

Demonstration of the generator proper together with some of the effects of the waves. Display of a collection of photographs from the researches on the generator.

Dr. H. JEFFREYS, F.R.S.—*Temperature conditions within the earth's crust* (12.30).

#### REPORTS OF COMMITTEES (12.40).

#### AFTERNOON.

Mr. H. L. P. JOLLY.—*Terrestrial magnetic bearings and their practical uses (with special reference to a new Magneto-Theodolite)* (2.15).

The usefulness of the magnetic bearing of an object depends upon the precision with which the magnetic declination at the time and place is known and upon the precision of the instrument with which the observation of the bearing is made. A new Magneto-Theodolite, incorporating the Smith fluid immersion (inverted pivot) mounting and a quick change-over from theodolite operation to magnetic reading and *vice versa* by means of pentaprism interposed in the telescope, is described. Tests have shown that the pivot is sufficiently free from friction to allow the instrument to follow changes of declination within fifteen seconds of angle or less. When working in sunlight or other conditions of rapid temperature change, convection may cause irregular movements of about a minute of angle.

The instruments work in pairs by simultaneous observation. Relative declination at a series of points may thus be quickly determined. If the distribution of declination in the area is already known, one instrument can be used to give true bearings from the magnetic bearing whilst the other, situated at a base station not very distant, makes simultaneous observations to control the time changes.

## DEPARTMENT OF MATHEMATICS (A\*).

Thursday, September 10.

Dr. OLGA TAUSKY.—*Modern problems in algebraic number theory* (10.0).

A few decades ago Hilbert emphasised the connection between the abelian extension fields of an algebraic number field and the division of the ideals of the base field into classes of equivalent ideals. Since then class field theory has become the main topic of algebraic number theory. Although class field theory is restricted to abelian fields only, two of the most fundamental questions of the general theory can be reduced to it. The first is the problem of enumerating all the extension fields of a field  $K$  in which the ideals of  $K$  become principal ideals. Furtwängler's principal ideal theorem asserts that the Hilbert class field is one of these extension fields. The second question, which is still unsolved, is whether there exists an extension field for every algebraic number field which contains only principal ideals. This question can easily be shown to be equivalent to the so-called class field tower problem, i.e. the problem whether the sequence  $K = K_0, K_1, \dots, K_n, \dots$ , where  $K_i$  is the class field of  $K_{i-1}$ , ends after a finite number of elements. Hilbert conjectured almost all the properties of class fields, but to prove his statements was by no means an easy task. That is particularly the case for the principal ideal theorem. This theorem is proved by means of a theorem on abstract finite groups. All the proofs of it which have been given use the methods of modern algebra. Using abstract group theory it is possible in some cases to prove the finiteness of the class field tower by a close investigation of the Hilbert class field and its subfields.

Dr. J. GILLIS.—*Some notes on the modern theory of measure* (11.0).

Linearly measurable plane sets are defined and their main known properties described. This leads to the division of these sets into two categories—regular and irregular. The former have all the fundamental properties of rectifiable curves while the latter are fundamentally different from them. It is irregular sets that are discussed here.

(1) It has been conjectured that such sets have zero projection (i.e. projection of zero measure) on almost all directions. A description is given of such parts of this conjecture as have actually been proved, including some hitherto unpublished results, and a discussion of their possible extension follows.

(2) It was known that, at almost all points of an irregular set, the upper density in every angle is positive. The problems which arise in the case of the lower density are discussed in relation to the known facts.

Dr. T. ESTERMANN.—*Some recent work in the additive theory of numbers* (11.30).

For every positive integer  $k$ , Hardy and Littlewood defined  $G(k)$  as the least number  $s$  such that every sufficiently large integer is a sum of  $s$   $k$ th powers (of positive integers). The object of this paper is to show that, if  $k \geq 4$ , then

$$(1) \quad G(k) \leq 2m + 7 + [2^{k-1}(k-2)(1-k^{-1})^{m+1}],$$



where

$$(2) \quad m = \left[ \frac{(k-2) \log 2 + \log(k-2) - \log k}{\log k - \log(k-1)} \right],$$

and  $[x]$  denotes the integral part of  $x$ . In particular  $G(4) \leq 17$ . This was recently proved by Davenport and Heilbronn and simultaneously by me, the method being essentially one of Winogradoff's refinements of the classical Hardy-Littlewood method. In this paper the same method is applied to the general case.

It follows from (1) and (2) that  $G(5) \leq 29$  and  $G(6) \leq 42$ .

Dr. P. ERDÖS.—*Note on some properties of sequences of integers* (12.30).

Let  $a_1 < a_2 < \dots < a_x \leq n$  be a sequence of positive integers such that no  $a_i$  is contained in the product of two other  $a$ 's of the sequence. Then

$$x < \pi(n) + O\left(\frac{n^{\frac{3}{2}}}{(\log n)^2}\right);$$

this error term is the best possible.

The proof is more intelligible if I first prove only that

$$x < \pi(n) + 2n^{\frac{3}{2}}$$

In this case the proof is based on the lemma:

Any integer  $m \leq n$  may be written in the form  $b_i c_j$  where  $b_i$  denotes any integer not exceeding  $n^{\frac{2}{3}}$  or any prime of the interval  $(n^{\frac{2}{3}}, n)$ , and  $c_j$  any integer not exceeding  $n^{\frac{1}{3}}$ .

To prove for  $x$  the more precise inequality we need a refined and rather complicated form of the lemma:

Now let  $\alpha_1 < \alpha_2 < \dots < \alpha_y \leq n$  be another sequence of positive integers such that the products  $\alpha_i \alpha_j$  are all different. Then

$$y < \pi(n) + O(n^{\frac{1}{2}})$$

The proof is based on our previous lemma.

Here the error term cannot be better than  $O\left(\frac{n^{\frac{1}{2}}}{(\log n)^{\frac{1}{2}}}\right)$ .

## Friday, September 11.

Dr. B. KAUFFMANN.—*Some recent results in general topology* (11.10).

Modern topology has developed from two originally independent subjects: combinatorial topology or *analysis situs* (in the sense of H. Poincaré) and the general theory of abstract spaces. The following stages of this development are considered in the first part of the lecture:

(1) Discovery of the combinatorial nature of the problems of general topology. J. W. Alexander's duality theorem and its generalisation by Lefschetz, Pontrjagin and others.

(2) Theory of simplicial approximations and transformations by Brouwer, Alexandroff and others. H. Hopf's fundamental result on essential transformations of complexes.

(3) Theory of dimension.

(4) P. Alexandroff's work on the internal structure of general spaces.

This last mentioned work of Alexandroff is the starting point of a new theory, which is outlined in the second part of the paper:

(1) First results on the infinitesimal structure of closed surfaces and the theory of harmonic transformations of complexes.

(2) Solution of the problem of intersections of algebraic complexes and arbitrary closed sets.

(3) Infinitesimal theory of general spaces and the principle of inductive linkages. The new Pfister theorems.

(5) Solution of Alexandroff's problem on homologies in the large.

In conclusion, some problems of general topology are discussed in the light of the new theory.

DR. A. C. OFFORD.—*Uniqueness theorems for trigonometric series and integrals* (12.10).

Cantor's fundamental uniqueness theorem for trigonometric series asserts that if

$$\lim_{m \rightarrow \infty} \sum_{-m}^m c_n e^{inx} = 0$$

for all  $x$  in  $(0, 2\pi)$ , then  $c_n = 0$  for all  $n$ . It is natural to suppose that there is a strictly analogous theorem for trigonometric integrals, and this is in fact true. Thus if  $\varphi(u)$  is integrable  $L$  in every finite interval and if

$$(1) \quad \lim_{\omega \rightarrow \infty} \int_{-\omega}^{\omega} \varphi(u) e^{ixu} du = 0$$

for all  $x$ , then  $\varphi(u)$  is equivalent to zero.

It is to be observed that the integral in (1) may converge for all  $x$  however great the order, or average order, of  $|\varphi(u)|$ . For example, it is convergent for all  $x$  when

$$\varphi(u) = \exp(\alpha u + i e^{u^2}) \quad 0 < \alpha < 1$$

Cantor's theorem has been generalised very widely by various writers, in particular by Rajchmann and Zygmund and by Verblunsky. There are corresponding results for trigonometric integrals and one of the most interesting of these is the following theorem.

If  $\varphi(u)$  is integrable  $L$  in every finite interval and if

$$\lim_{\omega \rightarrow \infty} \int_{-\omega}^{\omega} \left(1 - \frac{|u|}{\omega}\right) \varphi(u) e^{ixu} du = 0$$

for all  $x$ , then  $\varphi(u)$  is equivalent to zero.

Miss A. COX.—*On representation by squares and quadratfrei integers in a real quadratic corpus* (12.40).

Applications of the Hardy-Littlewood method to problems of additive arithmetic in algebraic corpora have been made by Siegel and others. In the present paper, which describes joint work of Dr. Linfoot and the author, Siegel's arguments (*Math. Annalen*, 87 (1922), 1-35) are applied to the problem of the representation of integers of large norm in a real quadratic corpus  $k(\sqrt{d})$  as a sum of squares and total-positive quadratfrei integers of the corpus, a quadratfrei integer of a corpus being defined as one not divisible by the square of a prime ideal of the corpus.

If  $I(t) > 0$ ,  $I(t') < 0$ , and

$$\theta(t, t') = \sum_{\mu} e^{\pi i S(\mu^2 t / \sqrt{d})}$$

$$f(t, t') = \sum_{\substack{\mu > 0 \\ \mu \text{ quadratfrei}}} e^{\pi i S(\mu t / \sqrt{d})},$$

then the number of representations of the integer  $v$  as a sum of  $s$  integer squares and  $r$  total positive quadratfrei integers of the corpus

$$A_{s,r}(v) = \frac{1}{\sqrt{d}} e^{-\pi i S(vt / \sqrt{d})} \iint_E \theta^s(t + 2u, t' + 2u') f^r(t + 2u, t' + 2u') \cdot e^{-2\pi i S(vu / \sqrt{d})} du du',$$

where  $E$  is the parallelogram in the  $(u, u')$ -plane defined by

$$u = x\omega_1 + y\omega_2, u' = x\omega_1' + y\omega_2', -\frac{1}{2} < x \leq \frac{1}{2}, -\frac{1}{2} < y \leq \frac{1}{2}$$

( $\omega_1, \omega_2$  a base of  $k(\sqrt{d})$ ;  $\omega_1', \omega_2'$  their conjugates) and we take  $t = i/\sqrt{Nv}$ ,  $t' = -i/\sqrt{Nv}$ .

We divide up the domain of integration  $E$  into regions  $F_\gamma$  by means of a Siegel  $F$ -dissection of order  $(Nv)^c$ , where  $0 < c < 1$  and the actual choice of  $c$  depends on  $r$  and  $s$ . Then

$$A_{s,r}(v) = \frac{1}{\sqrt{d}} e^{-\pi i S(vt / \sqrt{d})} \sum_{\gamma} \iint_{F_\gamma} \theta^s f^r du du',$$

where  $\sum_{\gamma}$  runs over incongruent  $\gamma \pmod{E}$  whose ideal denominators  $\mathfrak{a}$  are such that  $N\mathfrak{a} \leq (Nv)^c$ . The crucial step is to replace  $\theta, f$  by suitable approximation functions in the domains  $F_\gamma$ . For  $\theta$  we use Siegel's estimation

$$\left| \theta(t + 2u, t' + 2u') - \frac{G(\gamma)}{N\mathfrak{a}\sqrt{vv'}} \right| < K_1 \frac{e^{-K_2/N\mathfrak{a}\sqrt{Nv}|v||v'|}}{\sqrt{(N\mathfrak{a}|v||v'|)}};$$

for  $f$  we use the estimation

$$\left| f(t + 2u, t' + 2u') - \frac{\sqrt{d}}{\pi^2} \frac{1}{vv'} \sum_{\substack{\mathfrak{b} \equiv 0 \pmod{\mathfrak{a}}}} \frac{\mu(\mathfrak{b})}{\mathfrak{b}^2} \right| < K_3 N\mathfrak{a}(|v| + |v'|) Nv^{\frac{1}{2} + \epsilon} + K_4 N\mathfrak{a} Nv^{\frac{1}{2} + \epsilon}$$

here  $v = t + 2(u - \gamma)$ ,  $v' = t' + 2(u' - \gamma')$ , so that  $v, v'$  are small near the point  $(\gamma, \gamma')$ . The final result is:

$$\text{For } 0 \leq r \leq \frac{s-3}{2}$$

$$A_{s,r}(v) = \frac{\pi^{2r+s}}{\Gamma^2(r + \frac{1}{2}s) d^{r+\frac{1}{2}s-\frac{1}{2}}} Nv^{r+\frac{1}{2}s-1} S(v) + O(Nv^{r+\frac{1}{2}s-\frac{1}{2}})$$

as  $Nv \rightarrow \infty$ , where  $S(v)$  is a convergent 'singular series' whose sum depends on the arithmetical properties of  $v$  but lies between two fixed positive constants.

## Monday, September 14.

DISCUSSION on *The theory of complex atoms* (10.0).

Prof. D. R. HARTREE.—*Non-relativistic treatment of electronic structures of atoms.*

'Solar-system' approximation, in which mutual forces between electrons are first omitted and then included, is a perturbation, too crude to give significant results.



A simple type of approximation consists in reducing the many-body problem to a set of one-body problems, by considering the motion of each particle in some average of the fields of the others. The 'self-consistent field' approximation to the structure of an atom.

The variation principle and the relation of the 'self-consistent field' approximation to it. The inclusion of 'exchange' terms in the 'self-consistent field' approximation. Survey of results of calculations of self-consistent field, without and with exchange.

More accurate treatment of simple atomic systems, including dependence of wave-function on mutual distances between electrons, as well on their distances from the nucleus.

Dr. H. S. W. MASSEY.—*Laws of interaction between particles.*

Dr. BERTHA SWIRLES.—*The relativistic self-consistent field method.*

The development of a strict relativistic theory of an atom with many electrons presents much difficulty. It is, however, possible to extend the self-consistent field method, using Dirac's Hamiltonian for the separate electrons in the field of the nucleus and taking account not only of the Coulomb interaction but of the interaction of the spins and of retardation.

Tables have been constructed from which the total energy of an atom containing *s*-, *p*-, *d*-electrons can be calculated, taking account of 'exchange.' From this the relativistic self-consistent field equations can be derived by a variation method.

The method has been applied to the evaluation of the separation of the components of the  $2^3P$  term of helium. Slater's 'method of diagonal sums,' although not as powerful as in the non-relativistic case, shortens the work considerably. A comparison of the method and results is made with those of Breit, who used the relativistic wave equation in its second order form.

GENERAL DISCUSSION ON *The theory of complex atoms.*

Prof. M. R. SIDDIQI.—*The theory of non-linear partial differential equations* (12.20).

Non-linear partial differential equations have lately acquired considerable importance owing to the fact that they arise in various modern physical problems, such as the conduction of heat in crystals, and in deep seas, the field theory of Born, etc. Previous investigations dealing with such equations are mostly of a function-theoretical character, requiring a knowledge of the so-called 'Green's function.'

The present paper is devoted to developing a 'Fourier method' for the non-linear parabolic and hyperbolic equations:

$$\begin{aligned}\frac{\partial^2 u}{\partial x^2} - \frac{\partial u}{\partial t} &= \sum_{r,s}^{\infty} p_{r,s}(x,t) u^r \left( \frac{\partial u}{\partial x} \right)^s; \\ \frac{\partial}{\partial x} \left\{ p(x) \frac{\partial u}{\partial x} \right\} - \frac{\partial u}{\partial t} &= \sum_{r=1}^{\infty} p_r(x,t) u^r; \\ \frac{\partial}{\partial x} \left\{ p(x) \frac{\partial u}{\partial x} \right\} - \frac{\partial^2 u}{\partial t^2} &= \sum_{r=1}^{\infty} p_r(x,t) u^r.\end{aligned}$$

Various boundary value problems, as well as equations of higher order and systems of equations are also considered. Green's function is not required at all, and the solutions are given as series of characteristic functions. The Fourier coefficients are determined with the help of infinite systems of non-linear integral equations, which are solved by successive approximations. The uniqueness of the solutions is also established.

## SECTION B.—CHEMISTRY.

Thursday, September 10.

### CHEMISTRY AND THE COMMUNITY :—

PRESIDENTIAL ADDRESS by Prof. J. C. PHILIP, O.B.E., F.R.S., on  
*The training of the chemist for the service of the community* (10.0).

Mr. M. P. APPLEBEY.—*Industry and the profession of chemistry* (11.0).

The chemist's industrial importance is more widely appreciated every year but is yet not fully realised in some industries whose operations are largely chemical. The chemist may be of service in (a) analysis, (b) process control, (c) sales service, (d) research, (e) management. The use of fully trained chemists tends to efficiency, reduction of costs and profitable development. In regard to (e), a well-organised chemical education compares with other studies as a preparation for all the duties of management.

Industry depends on strong schools of chemistry, giving sound teaching of fundamentals and inspired by active research. Recruits for the chemical industry should have an honours degree and two or three years' research experience designed to give experimental training and to develop perseverance and resource. An industrial bias to the research undertaken in training is neither necessary nor desirable. Languages are almost indispensable, and men who have shared fully the general activities of their Universities are most useful.

The obligations of industry to the chemical schools are best discharged by the subsidising of research by research fellowships and by grants for special apparatus and chemicals. Industry should facilitate the active participation of its technical staff in the operations of the publishing societies, and should support the Chemical Council in improving publications, providing library facilities and generally promoting the consolidation of the chemical profession.

Mr. C. J. T. CRONSHAW.—*The benign gifts of organic chemistry* (11.30).

The science of chemistry has grown out of the earliest times ; but that part which we call organic chemistry is relatively a modern development. The discovery of mauve by Perkin and his commercial exploitation of his invention showed to the world the possibilities of this branch of chemistry. Upon this discovery Germany gradually erected a great and progressive industry. The uses of colour in a modern civilised world are so varied that it is difficult for a person to-day to look back and realise the meagre uses of colour before 1870.

The success of the dyestuffs industry showed in a very clear way the importance of organic chemistry as a tool in a modern world.

The practice of medicine has been enriched by this same tool : the whole range of local anæsthetics, many of the sleep-inducing compounds, and the sole remedy for sleeping sickness, are the results of this molecular architecture. Modern photography, particularly in the developers and sensitisers, is the gift of this branch of chemistry. The ubiquity of the motor car, in its fuel and its tyres, is a derived benefit from organic chemistry. It has given the textile industry two new fibres. Recently in its work on detergents and vitamins it still carries the torch. Always does it seem to have caused benign revolutions ; it appears still to be capable of causing others.

Sir HENRY DALE, C.B.E., F.R.S.—*The training of chemists for work in the fields of biochemistry and medicine* (12.0).

In recent years Chemistry has newly and rapidly invaded the fields of functional Biology and the sciences related to Medicine. Even in the study of the complex phenomena of immunity, the results of recent years have shown a beginning of exact description in terms of organic and physical chemistry. Up till about 1920 only some four hormones were known as separable entities, and of these only two had been chemically defined. In the last few years a whole series has been chemically isolated, and several have been made artificially by synthesis. Of the vitamins, known a few years ago only by the effects of their absence, four or five have been chemically identified, and at least three have been artificially prepared. Sex hormones, one vitamin, carcinogenic substances, and heart tonics have all been chemically related to the typically inert sterols. New synthetic compounds of chemotherapeutic value give promise of control over some of the most deadly infections of man, especially in the Tropics. The whole orientation of therapeutics is being shifted from the effects to the causes of disease. It is suggested that this new and increasing domination of biological and medical research, by chemical methods and ideas, represents the greatest of all the services of chemistry to the community. It calls for chemists of the highest ability, so trained that they can fully co-operate and share the planning of future progress with those primarily trained in biology and the medical sciences.

#### AFTERNOON.

Excursion to the Laboratories and Testing Departments of Imperial Chemical Industries, Ltd., at Blackley.

### Friday, September 11.

DISCUSSION on *Electroplating*. (See general summary below.)

Mr. D. J. MACNAUGHTAN.—*Introduction* (10.0).

Mr. A. W. HOTHERSALL.—*Development of control in electrodeposition processes* (10.15).

Dr. S. WERNICK.—*Electrodeposited coatings as corrosion preventives* (10.45).



Mr. E. A. OLLARD.—*Non-tarnishable finishes* (11.10).

Mr. C. F. J. FRANCIS-CARTER.—*Advances in industrial electroplating* (11.35).

Dr. H. J. T. ELLINGHAM.—*The future of electrodeposition* (12.0).

In the more restricted sense of the term, 'electroplating' consists in the production of a thin coating of a metal over the surface of a metallic object by passing a direct electric current through a solution of a salt of the metal to be deposited, the article to be plated being immersed in the solution and forming the negative electrode or cathode. This type of process is very closely related, however, to a number of others involving the electrodeposition of metals—the production of relatively very thick, strongly adherent deposits for 'building up' worn or undersized machine parts; the formation of an oxide coating on aluminium or its alloys by using the metal object as the positive electrode or anode in a suitable solution; the production of non-adherent deposits which, on detachment from the surface on which they are formed, reproduce faithfully details of surface structure (electrotyping) or the complete shape of an object (electroforming)—and the term 'electroplating' is sometimes used to include some or all of these cognate electrodeposition processes.

Although most of these various applications of electrodeposition were devised nearly a century ago, developments during the last twenty years have been so important that the scope and status of the industry have been completely changed. The papers presented at this meeting furnish a survey of the more important of these comparatively recent developments.

The range of metals electroplated has been extended by the important addition of chromium and recently of rhodium; 'anodising' of aluminium and its alloys has been introduced; and progress has been made in the simultaneous deposition of two metals to give alloy coatings. The electrodeposition of the 'base' metals, zinc and cadmium, essentially for the protection of iron and steel against corrosion, has become an important commercial process; and electrodeposited coatings of tin and, in special circumstances, of lead, have also been applied for this purpose. The scale of nickel plating has been enormously expanded, partly on its own account but chiefly because of the importance of nickel as an 'undercoat' for chromium; and the particular need for ensuring the deposition of firmly adherent, regular, non-porous nickel coatings for this latter purpose has greatly stimulated investigation of the factors which determine these properties, and has led to outstanding improvement in the quality and reliability of nickel coatings. The non-tarnishable finish imparted by a thin 'flash' of electrodeposited chromium to many classes of metal ware has received widespread application and has served to arouse a new interest on the part of manufacturers and members of the public in electroplating in general. The recent introduction of rhodium plating to furnish a non-tarnishable coating on silver ware bids fair to extend this interest. In the meantime, the old-established processes of plating copper, silver and gold have maintained their positions in their respective fields.

In all these developments important parts have been played by the metallurgist, the physicist, and especially the chemist. The importance of close co-operation between the research laboratory and the plating shop became fully recognised during the war, and is now accepted as the necessary basis for progress.

As a result of studies of the functions of various ingredients in plating

baths, some simplification of the older ' formulæ ' has been effected, and it has become possible to exercise a much more exact control over conditions of operation, and hence over the character and properties of the deposit. A better understanding of the influence of effective acidity (pH value) on the conditions of deposition, especially of nickel, has been vital to securing sound deposits of adequate thickness under modern conditions of mass production. The study of the factors enabling the plating process to penetrate into recesses in the object to be coated, instead of occurring unduly preferentially on projecting regions nearest to the anode, has led to the production of solutions for which this ' throwing power ' is high enough to permit the deposition of a reasonably even coating on articles of complicated shape. Investigations on the effects of ' addition agents ' of various kinds—especially colloids and other substances of high molecular weight—have resulted in the production of smooth, coherent coatings from solutions which otherwise yield coarsely crystalline, irregular, or spongy deposits ; and are now leading to the direct production of coatings so lustrous as to eliminate the need of polishing—a matter which may be of special importance when the size or shape of the article, or the properties of the deposit, render the polishing process difficult and costly.

Exact correlation of conditions of deposition with the character and properties of the deposit requires the provision of quantitative tests of properties of the coating such as hardness, porosity, internal stress and adhesion ; the introduction of such tests has furnished important information which enables these properties to be accurately controlled in practice and has led to developments in the use of electrodeposition for special purposes such as the electroforming of sheet and tube, the building up of worn machine parts and the provision of a hard facing on gauges, press tools, printing cylinders, etc. A further stage consists in correlating these properties with the crystalline structure of the deposit. Microscopical examination of etched surfaces and sections has done much to indicate the size, shape and general arrangement of the crystallites of which the deposit is built up, and even to detect the presence of non-metallic matter—e.g. oxides—which, entering the deposit in a colloidal state, may profoundly modify its crystalline character. Problems in this field involving the actual nature of adhesion of electrodeposits and the manner in which their structure is built up are also being attacked by X-ray examination and more recently by electron diffraction methods.

The striking improvements which have been made—especially during the last ten to fifteen years—in the control of the whole plating process, including the very important preliminary cleaning operations required to free the surface of the basis metal from traces of grease or other impurities which would prevent perfect adhesion of the coating, have raised the general standard of quality and reliability of plating to a remarkable extent and given users a real confidence in its value for a wide range of new industrial purposes. The resulting increase of demand has stimulated the introduction of mass-production methods for plating articles in automatic plants ; the articles to be plated are carried at a regular rate by conveyor chains through a succession of tanks and chambers in which the operations of cleaning, washing, plating, rinsing and drying are conducted in their proper sequence and each for its appropriate time ; such plants have become a feature of modern electroplating industry. An automatic nickel-plating plant may carry 3,000–5,000 gallons (or even more) of solution and as much as 5 tons of nickel anodes. It is estimated that the total area covered by nickel plate alone amounts to 250 million sq. ft. per annum.

Progress along the lines indicated may be expected to continue in the



future. Moreover, the practice of electroplating will no doubt be further modified and extended as a result of new advances in pure science, and the range of application of electrodeposited coatings widened by new developments in other industries.

In connection with this discussion an Exhibit of Electroplating, specially arranged by the Electrodepositors' Technical Society, was on view in the Chemistry Laboratory of the Grammar School, adjacent to Section B meeting-room, from Thursday, September 10, to Tuesday, September 15, inclusive.

#### AFTERNOON.

Excursion to Standfast Dyers and Printers, Ltd., Lancaster.

### Monday, September 14.

#### DISCUSSION on *Photochemistry*.

Dr. R. G. W. NORRISH, F.R.S.—*Introduction* (10.0).

Mr. H. W. THOMPSON.—*Molecular spectra as a guide to photochemical reaction* (10.30).

The earlier measurements on photochemical reactions were made largely to determine the quantum efficiencies of the reactions from the standpoint of the Einstein Law. The development of the theory of reaction chains from the study of the effect of inhibitors, the high values of the quantum yields, and other considerations, made it clear that there are two essential parts to a photochemical change: (1) the primary process; (2) secondary processes, which are quite independent of the primary one. It is with the so-called 'primary processes' that spectroscopic considerations are mainly concerned, for it is clear that the nature of the absorption spectrum of the reacting substance must be a guide to the manner in which the light energy is absorbed. This correlation of absorption spectrum data with photochemical measurements has perhaps been the most significant advance in the subject in recent years.

Briefly, it can be said that the main problem is to decide whether the primary process involves mere excitation, or one-act dissociation. The spectral evidence often makes a decision between the two alternatives possible, although there is in some cases, especially with polyatomic molecules, some ambiguity. Spectral evidence also makes it frequently possible to determine the products of a primary one-act dissociation, but the limitations of this raises many crucial questions.

In the present paper the nature of the energy levels of a diatomic molecule and the theory of the structure of an ideal absorption spectrum are outlined. The significance of potential energy curves is discussed. Three types of absorption spectrum are found in practice, (a) those which are fine-structured or discrete throughout, (b) those which are entirely continuous, and (c) those which show either diffuseness throughout or have both discrete and diffuse regions. The more important examples of each type are given, and their interpretation in connection with typical photochemical processes is discussed. In particular, the class of 'predissociation spectra' is described, and inferences drawn from them are explained.



The deduction from the purely spectral data of products of primary dissociation is discussed, and attention is drawn to the ambiguities and limitations of the interpretations already given. The necessary supplementary evidence is indicated.

The above considerations are carried over to the more general cases of polyatomic molecules, with which photochemistry is mainly concerned. The interpretations are applied to certain photodecompositions which have recently been studied, such as the photolysis of metallic carbonyls, allyl aldehyde, carbon suboxide, alkyl nitrites, metallic alkyls and others.

Questions of a general nature bearing upon the above, such as energy degradation within a molecule, reactions of low quantum yield, the significance of different modes of induced molecular vibration, and the nature of the products of primary one-act dissociation, are discussed.

Dr. T. G. PEARSON.—*The photochemical generation of free radicals* (11.0).

Dr. R. G. W. NORRISH, F.R.S.—*Photochemistry of polyatomic molecules* (11.30).

Dr. H. W. MELVILLE.—*Secondary reactions in photo-chemistry* (12.0).

Nearly all photo-chemical reactions are complex, that is the primary process—the absorption of a quantum of radiation—is succeeded by a series of reactions which require separate investigation. This has been accomplished with a number of photo-reactions, for example, the photo-dissociation of ammonia and the photo-synthesis of hydrogen bromide and the deviations from the low photo-chemical equivalence explained.

On the other hand when the primary process has been thoroughly elucidated the photo-technique may be utilised to study the kinetics of thermal reactions whose mechanism cannot otherwise be unambiguously settled. Among the processes which may be studied in this way are the rate of recombination of free atoms, the exchange reaction of deuterium with hydrides, the thermal decomposition of polyatomic molecules, the kinetics of the formation of substances of high molecular weight by polymerisation of simple molecules and the mechanism of slow and explosive combustion.

#### AFTERNOON.

Dr. R. G. W. NORRISH, F.R.S., and Dr. H. W. MELVILLE.—*Experimental demonstration illustrating the principles of photochemistry.*

### Tuesday, September 15.

#### CHEMISTRY AND FOOD SCIENCE :—

Dr. L. H. LAMPITT.—*The scientific aspect of the preparation of food* (10.0).

Dr. L. J. HARRIS.—*The nutritional aspect* (10.30).

The final criterion by which the work of the food chemist must be judged is Nutrition—does the food afford adequate nourishment? Chemical research has led to striking advances, such as are exemplified in the isolation,

the determination of the structure of, and the artificial synthesis of vitamins. As a result the clinician can now prescribe an exact number of International Units of a synthetic vitamin ; and Nutrition is becoming an exact science instead of a matter of opinion. But the study of nutrition involves also the use of biological, and physical, and other methods, and this justifies and indeed necessitates the existence of a new scientific expert—the nutritionist. Nutrition in its applications is also bound up with agriculture and economics. The nutritional condition of the people as a whole is better than it was, but there is ample room for further improvement. A difficulty in assessing malnutrition in the past has been the lack of standards of reference, but newer chemical and clinical methods for determining partial deficiencies are now offering themselves. Evidence of malnutrition, presumptive or direct, is obtained along several different lines—viz. (1) economic (i.e. insufficiency of money spent on food), (2) dietetic (inadequacy of food eaten), (3) medical (existence of disorders of deficiency), (4) sociological (comparison of the health standards of poorly-fed and better-fed social groups), and (5) experimental (improvement in health observed in controlled tests when the inadequate food is suitably augmented).

Dr. T. MORAN.—*The biology of food preservation* (11.15).

Food storage is the link between the farmer and consumer ; it dates from earliest times, but modern civilisation, with industry and farming each concentrated and often separated by oceans, has greatly increased its importance.

The aim of food storage science is not simply to maintain the condition of the foodstuff as it exists on the farm, but instead to modify and control changes so as to yield, after a predetermined interval, pleasant and desirable foods.

The demand for standard products which are also best suited for storage has exercised, and continues to exercise, a profound influence upon the theory and practice of farming which is, in fact, being industrialised.

Foods consist of living materials, such as fruits, vegetables and cereals ; and dead but still complex and organised structures such as meat and fish. The properties and behaviour of these foodstuffs during storage are discussed to illustrate on the one hand the breadth of the scientific background, and on the other types of practical applications which have emerged from the laboratory.

Food science can be regarded as a distinct branch of teaching and research, coming between agriculture on the one hand and medicine on the other.

Mr. T. M. HERBERT.—*Transport of food* (11.45).

A brief historical survey shows that whilst there have in past ages been examples of dependence on food imports, problems of food transport hardly achieved serious importance until the industrial era. Since this date Great Britain has occupied a unique position in the world trade in foodstuffs, and the magnitude of the problems involved in supplying her requirements is indicated statistically. The development of the world trade in wheat, and the much more difficult problem of ensuring this country's meat requirements between 1870 and 1900 is outlined.

The present-day problems relate mainly to the conveyance of perishable foods requiring controlled conditions of transport. Maintenance of suitably low temperatures, or provision of adequate ventilation, are the primary requirements that the chemical engineer has to solve, and the refrigeration



methods adopted on shipboard and on rail or road vehicles are discussed. Various classes of foodstuffs are then considered, and the particular problems arising in their conveyance are outlined, and examples of their successful solution given.

Finally, the part that transport can play in ensuring an adequate diet is stressed as an example of co-operation between chemist, physicist and engineer in the service of the community.

DISCUSSION (Sir JOSIAH STAMP, G.C.B., G.B.E., Prof. H. G. DENHAM, Dr. G. ROCHE LYNCH, O.B.E., Dr. A. J. SMITH, and others).

## SECTION C.—GEOLOGY.

EXCURSION PRECEDING THE MEETING. (September 5-9.)

By the invitation of the Yorkshire Geological Society, members were able to join in an excursion to Ulverston before the meeting. The party numbered about forty. The late Dr. Bernard Smith was to have been one of the directors—his place was taken at short notice by Mr. T. Eastwood. Mr. T. C. Nicholas, Dr. R. G. Hudson, Prof. W. B. R. King and Dr. G. H. Mitchell were the other directors. The excursion included visits to the Duddon Valley, Coniston and Ashgill, Hodbarrow Hæmatite Mine, Humphrey Head and Arnside, and were uniformly successful and enjoyable. The organisation of the excursion, by the Excursions Secretary of the Society, Dr. Mitchell, was admirable, and the weather conditions, though representative of those normal to the district, were far from unsatisfactory.

### Thursday, September 10.

Prof. H. H. READ.—*Geology of the neighbourhood of Blackpool* (10.0).

Dr. R. G. S. HUDSON.—*The Lower Carboniferous south of Carnforth.*

An important structure, the Hutton monocline, extends from Priest Hutton to Quernmore and forms a N.-S. belt of vertical rocks, 8 miles long and often about 800 yards wide. The axis of the fold crosses the general strike of the Carboniferous rocks and therefore while in the northern part of the fold the vertical beds are  $D_1$  limestone (as at Wegber and Capernwray Quarries), in the southern part of the fold the steeply dipping beds are Bowland Shales and Millstone Grit (as at Kellet Park Wood and Addington Quarries). The Hutton monocline is parallel, and of a similar nature, to the Dent monocline to the east and the Silverdale monocline to the west.

Near Carnforth and Over Kellet the Carboniferous Limestone is of  $S_2D_1$  age and is bedded limestone of Great Scar (massif) facies. Southwards the bedding disappears and along the line Bolton-le-Sands and Dunald Mill the limestone is of reef facies, and a reef-knoll topography is slightly developed. Transition limestones between Great Scar and Reef facies are exposed in Dunald Mill Quarry, while a small fold at Swantly to the west of the Hutton monocline exposes a knoll of  $D_1$  reef-limestone. Farther south a similar inlier at Halton Green exposes  $D_1$  limestone of



Craven Lowland (basin) facies together with limestone breccias similar to the D<sub>1</sub> breccias of that area.

These E.-W. belts of Viséan sedimentation are comparable to those of the Craven area and thus extend the Craven Reef Belt to the west under Bowland Forest and link it with its western extension in the Isle of Man.

The beds between the Carboniferous Limestone and the Millstone Grit show a transition southwards from a shale, sandstone, limestone (Yoredale) facies well exposed in Pinfold and Sellet Hall Becks to a shale (Bowland) facies exposed in Kellet Hall Wood. Along the reef belt as at Swantley the shales are overlapped and Millstone Grit rests almost directly on the reef limestone.

Mr. F. C. SLINGER.—*Millstone Grit and glacial geology of Caton Moor, near Lancaster* (11.30).

A series of grits and shales of Millstone Grit age, and ranging from lower E<sub>2</sub> to R<sub>1</sub>, are exposed on or near Caton Moor. The succession is as follows :

|   | Ft.     |
|---|---------|
| Moorcock Flags and Hawkshead Grit . . . . . | 100     |
| Claughton Moor Shales . . . . .             | 100-40  |
| Nottage Crag Grit . . . . .                 | 100-50  |
| Claughton Flag Series . . . . .             | 200-100 |
| Caton Shales . . . . .                      | 100     |
| Roeburndale Grit with thin coals . . . . .  | 50      |
| Close Hill Shales . . . . .                 | 150-0   |
| Cocklett Scar Flags . . . . .               | 150-10  |
| Wray Grits and Shales . . . . .             | 50      |

A boulder bed at the base of the Cocklett Scar Flags (i.e. near base of E<sub>2</sub>) indicates contemporaneous local movement. The Roeburndale Grit, the upper layers of which are usually ganisteroid, contains two thin and impersistent coals. The Caton Shales, the 'calcareous shales' of the 1 in. Geological Survey map, contain goniatites of late E<sub>2</sub> age; the uppermost band contains *Cravenoceras holmesi*, *Anthracoceras discoides* and *A. cf. paucilobum*. The Claughton Flag Series (sandy shales and thin carbonaceous sandstones) contains a sparse fauna of marine lamellibranchs. The Claughton Moor Shales are also in part marine.

*Correlation.*—The Roeburndale Grit may be correlated with the Red Scar Grit of Upper Nidderdale; the Claughton Flag Series represents both the Follifoot Grits and the Cayton Gill Beds. The Claughton Moor Shales probably represent the lowest shale in the Brimham Grits of Nidderdale and the shales with *R. eoreticulatum* and *R. inconstans* below the Addlethorpe Grit of the area south of Harrogate.

An olivine dolerite dyke of Tertiary age is intruded into the Caton Shales.

Glacial retreat phenomena are particularly well developed, and the positions of several minor halt stages can be determined.

Mr. L. H. TONKS.—*Geology of the Preston district* (12.0).

Dr. J. E. RICHEY and Dr. W. Q. KENNEDY.—*The succession of the Moine Schists of Western Inverness-shire.*

A stratigraphical succession has been established in the Moine Schists along the coastal region of western Inverness-shire between Mallaig and

Arisaig.<sup>1</sup> The schists concerned lie not far to the east of the Moine Thrust. They fall into three groups, as follows :—

3. Upper Psammitic Group.

2. Striped and Pelitic Group { (c) Upper Striped Schists with calc.-silicate layers.  
(b) Pelitic Schists.  
(a) Lower Striped Schists.

1. Lower Psammitic Group.

The above groups are here termed, collectively, the Morar Schists, and form a single stratigraphical series with interbanding along their mutual junctions. The original order of deposition is shown in the psammitic schists by abundant false-bedding, by recurrent slip-folding, by ripple-marking, local erosion and the downward penetration of sandy material into fissures from an overlying bed. In the striped schists of Group 2, which consist of alternating laminæ of psammitic and pelitic or semi-pelitic material, false-bedding on a small scale and ripple-marking are sometimes seen in the psammitic layers.

Older beds are encountered in a direction eastwards from the coast without repetition by folding of any consequence. The total thickness of the Morar Schists must be immense. An estimate of 19,000 ft. has been made, but no stratigraphical top or base to the series is known.

The lowest group (1) is in contact eastwards with much crumpled and folded schists or gneisses. These form an anticlinal core with N.-S. axis. In Knoydart both to west and east Group (1) is succeeded by the Striped and Pelitic Group (2), which on the eastern side is injected with granite-pegmatite and thus forms injection-gneisses, which cover a wide area in Knoydart and eastern Morar.

The rocks of the anticlinal core are mainly paragneiss, but include a broad belt in which hornblendic and feldspathic bands are prevalent. The structural succession is as follows :—

- (d) Psammitic gneiss.
- (c) Striped pelitic-psammitic gneiss.
- (b) Banded hornblende-gneiss, etc.
- (a) Psammitic gneiss, with epidote-rich bands plentiful near top.

Along the junction of the gneissic core with the Lower Psammitic Group (1) of the Morar Schists, the Psammitic Gneiss (d) and the Striped Gneiss (c) are locally absent. The junction appears to be a plane of discordance.

#### AFTERNOON.

Excursion to Preston district. Leader, Mr. L. H. TONKS.

### Friday, September 11.

Dr. O. H. SCHINDEWOLF.—*Chapters from the phylogeny of the Cephalopoda* (9.45).

DISCUSSION on *The geomorphology of the Irish Sea Basin* (10.15).

Prof. J. K. CHARLESWORTH.—*Introduction.*

The Irish Sea Basin is the result of an age-long evolution. Tectonic forces of Caledonian age raised the Lower Palæozoic sediments into the

<sup>1</sup> Richey, J. E., in 'Summary of Progress for 1935, Part I' (*Mem. Geol. Surv.*), 1936, pp. 78-79.

discontinuous ring about the basin and initiated the tectonic depression of Strangford Lough and that south of Co. Down which continues into the Solway. The Carboniferous Limestone sea was in some respects the precursor of the present Irish Sea, for the mountains of Wales, Wicklow, the Lake District and the Isle of Man rose above its surface though the Coal Measure swamps largely surmounted them. Hercynian folding and faulting again emphasised the morphological difference between hill and plain which the Keuper Marls and Jurassic strata later did so much to minimise. The close of the Cretaceous coincided with the beginning of the present drainage.

During the Tertiary Era that witnessed the birth of the Mourne basin was the scene of fracturing, as in the North Channel and Carlingford Lough, and of intermittent elevation, for levels of planation, three at least in number, are still preserved. The last of these, of early Pliocene age, was succeeded by further uplift which initiated the 'buried valleys.'

Pleistocene ice sculptured the uplands and deposited its load on the sea-floor and the surrounding plains, converting parts of the floor into dry land, obliterating the 'buried valleys,' and largely obscuring the 'preglacial' shoreline. In recent times, the sea withdrew into a narrow channel and expanded subsequently to inundate the 'submerged forests' and separate Ireland and the Isle of Man from Great Britain.

Dr. E. GREENLY.

On the floor of the sea to the east of Anglesey are sheets of Mesozoic rocks, with an outlier of Chalk; so this is the site of a Neozoic syncline. Anglesey (before base-levelling) was the core of an anticline. But it was a mere lobe. For Snowdonia is carved out of a plateau, whose last base-levelling seems to have been in Late Cretaceous time. Now raised into a very gentle dome, it is the core of a far loftier anticline. Further, the valleys of Snowdonia cannot have existed at the time of the intrusion of certain dykes, which are of Neozoic age. Consequently, the mountains, as mountains, must have begun to develop at some stage of Neozoic time; probably Oligocene, possibly Miocene. For the Menaian Platform cannot be later than Pliocene. Thus, none of the major features of the south-east part of the Irish Sea Basin can be anterior to Oligocene time. They are the work of prolonged erosion acting upon gentle Neozoic folding.

Mr. R. KAY GRESSWELL.—*The south-eastern portion of the Irish Sea Basin.*

Having found that foreshore drifting occurs on the south-west Lancashire coast away from Formby Point in both directions (see paper to Section E at this meeting), the conclusion is reached that material is brought from the sea floor to the beach at Formby Point, and also since the bottom to the 10-fathom line is more or less pure quartz sand, this indicates that submarine contours to this depth will be controlled by present-day currents. From the 10- to the 30-fathom line in an east-west direction is about 43 miles, giving an average gradient of 3 ft. a mile or 1 in 2,000 approximately. The submarine contours here are intricate but indicate possible post-glacial estuaries for the rivers Ribble, Mersey and Dee between the 16- and 25-fathom lines. The Mersey and Dee appear to unite at 25 fathoms. The presence of submerged forestal remains on the Formby to Liverpool and Wirral coasts shows that in post-glacial times the land stood higher than to-day, 120 ft. having been suggested by De Rance. Thus the determination of the post-glacial coastline is of importance. It is, however, possible,



in view of the unconsolidated nature of the sea bottom, that the whole of the submarine relief discussed here may be due to currents at present in operation.

Mr. A. AUSTIN MILLER.—*Pre-glacial erosion surfaces round the Irish Sea coast.*

The pre-glacial surface is much obscured by thick accumulations of drift on the lowlands and considerably modified by ice erosion on the highlands, but sufficient evidence survives to permit an analysis of slopes and drainage systems with a view to determining the base levels to which they are graded. A correlation is attempted of evidence collected from the Irish Plain, the Wicklow Mountains, North Wales, the Lancashire Plain and the Lake District.

Three erosion cycles are recognised, and the features correlated with each cycle are separated and described. The obliteration of much of the evidence by glaciation and its interference with such as survives forbids any precision in assessing the earlier base levels, but they appear to indicate successive sea-levels at about 600 ft., 400 ft. and 200 ft. above that of to-day.

Dr. S. E. HOLLINGWORTH.—*Platforms around the Lake District.*

The Lake District and its environs form a well-defined structural and topographic unit bounded by sea on three sides. The superimposed radial drainage has been considered to have developed on domed Mesozoic or Tertiary rocks covering an old planation surface.

Several well-defined plateaux or platforms have been cut in the varied rocks beneath this surface of planation.

Investigation in the field and by means of projected profiles, etc., revealed additional evidence suggestive of the presence of a number of variably developed platforms at intermediate and higher levels. This increase in the number and frequency of possible platform levels made the danger of faulty linking-up, by invoking or overlooking warping, very real.

It became necessary to subdivide the area into narrow, more or less radial strips, and investigate each separately. Results appear to indicate that individual levels persist *around* the Lake District, thus excluding any considerable tilting (except possibly accentuation of doming) since the formation of the highest (2,600 ft. O.D.) platform. Watershed profiles yield confirmatory results.

Within the less glaciated valleys the 'valley within valley' character is often recognisable and may in exceptional cases be linked with steps in the valley floor.

In the more severely glaciated valleys, some steps that have developed by ice-plucking, probably originated at limits of rejuvenation; and some correlation between these is possible.

The recognition of the platforms in a heavily glaciated area appears to give a definite limit to the amount of ice erosion.

The platforms cut on the outer slope of the dome are considered to be of marine origin with subaerial equivalents inland. They probably date from early Pliocene or late Miocene times.

Many cols correspond with platform levels and some river captures appear to be associated with rejuvenations that followed the uplift of particular platforms. Throughout the area glacier-lake overflows across spurs tend to occur at the inner edge of platforms.

Many of the platforms can be plausibly linked with others farther afield

at similar heights. If such correlations are ultimately made, the great range of eustatic movement suggested thereby must fundamentally affect many aspects of Neozoic geology and geography.

#### AFTERNOON.

Excursion to Dinkley on the Ribble. Leader, Mr. E. W. J. MOORE.

### Saturday, September 12.

Excursion to the Lake District, for Skelgill. Leaders: Profs. W. G. FEARNSIDES, F.R.S., and W. B. R. KING.

### Sunday, September 13.

Excursion to Lancaster Fells. Leaders: Dr. R. G. S. HUDSON and Mr. F. C. SLINGER.

### Monday, September 14.

PRESIDENTIAL ADDRESS by Prof. H. L. HAWKINS on *Palæontology and humanity* (10.0).

DISCUSSION on *Earth movements in Carboniferous times in North England*.

Prof. H. G. A. HICKLING, F.R.S.—*Discussion on earth-movements in the north of England*.

The geological structure and topography of the north of England is based upon the powerful folding of the lower Palæozoic rocks. In the west these folds follow the usual N.E.-S.W. trend, but under the east they appear to trend consistently N.W.-S.E. The change of strike follows the Vale of Eden and the upper Ribble. It is probably continued southward under the eastern edge of the Lancashire and North Staffordshire coalfields, and possibly farther south by the line of the Malvern disturbances. Based upon this structure, the Carboniferous rocks west of the line are dominated by folds of Caledonian trend, illustrated by the Cumberland coalfield, the powerful folds of the lower Ribble valley and the Burnley and South Lancashire coalfields. Correspondingly, the dominant faulting in this area is N.W.-S.E. East of the line the Carboniferous folding is gentler and is characterised by Charnian trends, illustrated by the synclines of the Durham, Yorkshire and Nottingham coalfield. The dominant faulting on this side is N.E.-S.W.

The 'Pennine Chain' probably owes its inception to a stiffening of the country about the line of change in the lower Palæozoic folding. It consists of four domed elevations, with summits near the High Peak, Ingleborough, Cross Fell and Bewcastle respectively. The great domes of the Cheviot and the Lake District are not on the line and are probably of different origin. There is evidence that some of these domes were indicated in the pre-Carboniferous topography, but in the main they were produced by intra-Carboniferous movements. All workers on both lower and upper Carboniferous rocks have emphasised the abundant evidence of movement



during their deposition indicated in detail by numerous local unconformities, erosional features, boulder beds and slumping phenomena, and on the great scale by very great variation in the thickness and character of the deposits. The essential structure of the region was completed before the Permian peneplanation. There is no evidence of more than a broad warping of the north of England since Carboniferous times, with some considerable faulting in the neighbourhood of the divisional line previously mentioned. The present topography and drainage shows a remarkably close adjustment to the Carboniferous tectonics. This fact, together with the low degree of alteration of the rocks themselves, suggests that the Mesozoic cover has never been of great thickness, and that it has done little more than protect a pre-Permian topography of which the main lines are now re-emerging.

Dr. R. G. S. HUDSON.—*Sudetic earth-movements in the Craven area.*

In the Craven area of Yorkshire, an area of Carboniferous sedimentation in basin and on massif, the Mid-Carboniferous (Sudetic) orogeny consisted of movements commencing in the Upper Viséan and persisting to the end of the Lower Namurian. These orogenic phases can be correlated with changes in type of sediment action and vary both in character and in their relation to basin, margin and massif.

*Early Sudetic movements* have their major effect in the sedimentation basin and resulted in general uplift followed by sharp folding along E.-W. axes, best seen in the Skipton anticline where the main movement is of  $D_1/P_1$  age. On the massif and on the reef-belt of the massif margin these movements are indicated by intraformational breccias and conglomerates.

*Middle Sudetic movements* show the transference of the main effect from basin to the margin between basin and massif. They are of both  $P_1/P_2$  and  $P_1/E_1$  ages and resulted in down-folding and down-faulting of the basin along the margin; the former in front of the reef-belt and the latter (the Mid-Craven Fault) at the back of the reef-belt, both being accompanied by slumping, the formation of boulder beds and the rapid transgression of the succeeding shales across the knoll topography and fault-scarps thus formed. Probably the extrusion and slumping of the Scarlet lavas of the Isle of Man margin are of this age. In basin and on massif these movements are mainly expressed by change of sediment accompanied by local non-sequences.

*Late Sudetic movements* mainly affected the massif. Two movements resulted in the unconformity of the Millstone Grit (Grassington Grit) on the Yoredale Series and later the non-sequence between the Grits of Tan Hill and the Mirk Fell beds below. These movements have only been recognised in the basin by the thinning of the sub-Kinderscout beds against the massif.

This northward shift of the major effects of the various Sudetic movements was continued during the succeeding Erzgebirgian orogenies and resulted in the absence of the greater part of the Upper Namurian in Northumberland and Durham.

Mr. R. C. B. JONES.—*The Lancashire coal-field between the Rossendale anticline and Cheshire basin.*

The South Lancashire Coalfield has a general southerly dip which is much interrupted by folds and faults. Its eastern limit is the Pennine Anticline while to the west the Rossendale Anticline loses its influence and the Carboniferous is faulted against the Triassic. The main coalfield is here



limited by the Knowsley Anticline, the detached Skelmersdale Basin lying to the north of it.

It has been found impossible to analyse some of the folds and associated faults. It can be shown that folding, but not faulting, took place before the Upper Coal Measures were deposited which here rest unconformably on the Middle Coal Measures, over 2,000 ft. of which are missing.

The parallelism between the unconformable bases of the Upper Coal Measures and the Permo-Trias suggests that there was little folding prior to the deposition of the Permo-Trias although faulting took place. The major faulting occurred in post-Trias times and was mainly a renewal of movement along pre-Triassic faults. The relatively small dips in the Upper Coal Measures and Trias compared with the Middle Coal Measures beneath indicate that the folding was mainly pre-Upper Coal Measures.

There are indications of movement during the deposition of the Middle Coal Measures.

Dr. G. H. MITCHELL.—*The Skipton anticline.*

#### AFTERNOON.

Excursion to Bispham and Upholland. Leaders: Messrs. R. W. CHALMERS and L. H. TONKS.

### Tuesday, September 15.

Prof. H. P. LEWIS.—*Ordovician succession at S.W. end of Aran range, Merionethshire (10.0).*

The area is that drained by the Helygog and Celynog, tributaries of the Afon Wnion. It consists of Upper Cambrian and Ordovician rocks which dip, in general, to the south-east, and which are crossed by the Bala Fault. The Ordovician sequence, with approximate maximum thicknesses of the subdivisions, is as follows:

*Arenig or Basement Series* (900 ft.).—Gritty and micaceous flags, slaty tuff, bedded and massive felspathic tuff and, at or near the top, the 'Aran Boulder Bed,' in which the tuff contains abundant large boulders of 'felsite.' South-east of the Bala Fault, the lowest beds are separated by a sill of dolerite from grey flags of Tremadoc age (with *Asaphellus homfrayi*), in the Celynog section, and faulted against Tremadoc rocks containing *Dictyonema* and *Acrotreta* in the Helygog.

*Llanvirn Mudstones and Flags* (350 ft.).—These follow the Basement Series with apparent conformity and consist largely of dark-blue, pyritous mudstones, but in the lower part, in particular, bands of fine siltstone and occasional thin ash-bands, or scattered fragments of pyroclastic felspathic material, occur. The mudstones have yielded *Calymene* sp., *Cryptograptus tricornis* (?) and graptolites of the *Didymograptus bifidus* group including *D. c.f. artus*. These mudstones pass up into tough, blocky, blue mudstones with dendroid graptolites, and, south of the Bala Fault, into micaceous and pyritic flags in which crinoids, *Ogyginus* cf. *corndensis* and *Trinucleus* occur in addition, thus lithologically and faunally suggesting equivalence with the Upper Llanvirn of western Shropshire.

*The Main Pyroclastic Group* (1,800 ft.). Llandeilo-Caradoc (?).—Most fully represented west of the Celynog, where it is subdivided into three

groups of tuff and agglomerate with spilitic rocks and mudstones. *Amplexograptus perexcavatus* and *Dicellograptus* sp. occur.

*The Upper Rhyolitic Group* (1,500 ft.). Caradoc (?).—This, like the Upper Acid Group of Cader Idris, consists mainly of massive and streaky rhyolitic tuffs. It is followed by the Ceiswyn slates and mudstones.

Sills of dolerite affect each of the rock series named and occur as high as the summit of the Upper Rhyolitic Series. Intrusive rocks of acid composition are represented.

## DISCUSSION on *Coal Measure correlation* (10.30).

Prof. A. E. TRUEMAN.—*The correlation of the Coal Measures.*

Problems of correlation in the Coal Measures involve both the recognition of zones and the identification of individual horizons. In comparing sequences in different coalfields, in recognising strata met with in new explorations (especially of concealed coalfields) and in the interpretation of structurally complex areas, the identification of floral or faunal zones is of outstanding importance; the recognition of datum planes and correlation on a more detailed basis is more often necessary in actual mining operations.

Within the last ten years work on the faunas and floras of the Coal Measures and on the coal seams has provided a basis for the solution of most of these problems. The charge of neglecting the stratigraphy of that formation which is of most economic importance can no longer be justified.

In many instances minute palæontological studies have confirmed the correlations which had been based on thicknesses and on comparisons of sections, but in other cases erroneous conclusions had been drawn from such data. The broader divisions made by palæobotanists probably hindered the development of real floral zones.

The peculiar conditions under which the Coal Measures were laid down and the surprising uniformity of many horizons (coal seams, marine bands, etc.) over wide areas facilitate correlations even when the fossils would at first sight be thought unsuitable for detailed work.

Dr. W. B. WRIGHT.

The position as regards the correlation of the Coal Measures of Great Britain has improved greatly during the last ten years and there is now a real hope that fairly precise identification of horizons may ultimately be attained.

An important advance at the beginning of this period was Prof. Trueman's revision of the non-marine lamellibranchs. The zones established by him are, however, very broad and identifiable with difficulty. Their limits are moreover indefinite and although a general correspondence in the succession can be traced from coalfield to coalfield, little precision is obtainable by their application. One zone in particular is wanting in the north.

Within the limits of the Lancashire field a more accurate result has been obtained by a system of subzones. These lead to exact identification of seams only in two or three cases, not always accessible. The range of error in local correlation by subzones varies from precision up to several hundred feet, even where material is available. As regards correlation with other fields equivalence is suggested by the subzonal forms on a few horizons but not accurately.

For exact correlation both locally and between fields something else is required, and recent researches into the spore-content of coals afford



reason to hope that precision may be possible on certain horizons after much work.

Dr. Slater and his assistants have, however, of recent years greatly accelerated their methods by examining polished surfaces of the coal by incident light, and at the same time simplifying their diagrams. In this way they have succeeded in comparing a number of sections within the Yorkshire field and getting comparable results with the same seam. The particulars are, however, as yet unpublished.

Dr. Raistrick's method by separation of microspores is a distinct advance in that it enables abundant material to be examined, so that seams of supposed identity can be shown to be not merely like one another but different from all others with which they might be confused. The method is being exhaustively tested. The results are extremely promising, but there are a number of pitfalls which still need careful investigation. Methods of treatment must be carefully standardised if comparable results are to be obtained; the classification of spores is far from satisfactory; the personal factor in observations enters in some degree into the results, and finally, if there is a marked change in the physical character of the seam the spore content varies accordingly.

Dr. Raistrick's results in Northumberland, however, seem to show that quite reliable correlation can be obtained within the field, and those investigations which he has up to the present made in Lancashire promise similar results.

#### Dr. EMILY DIX.

In many cases, the non-marine and marine fossils form the most reliable indices for detailed correlation, yet at certain horizons the plants are so characteristic that they are quite as important for zonal purposes as the non-marine shells. In areas where their use is difficult, especially in the upper measures, the evidence afforded by the plants is particularly important. Dr. Kidston showed that plants could be used for subdividing rocks of coal measure age; subsequently further studies on fossil floras have substantiated this view. The Upper Carboniferous rocks of South Wales can be divided into nine floral zones (two of which are confined to the Millstone Grit). In defining each zone the whole of the floral assemblage has been considered, although certain species have much greater value for purposes of correlation than others. In general the succession of plants in the South Wales Coal-field agrees very closely with that of other coalfields in Great Britain, and also with that of corresponding strata on the Continent and in North America, as shown by the work of Bertrand, Gothan, Jongmans, Renier, Darrah and others.

For many years it was recognised that the correlation of the coal measures based on the faunas was not in agreement with the results obtained by workers on the plants. This discrepancy does not exist. In the upper part of the Millstone Grit and the lower part of the Coal Measures distinctive floras are found in every coalfield in Britain where the sequence is known, which are comparable with those found in the zone of *Neuropteris schlehani* and *Sphenopteris hoeninghausi* on the Continent.

It appears that certain floral changes took place more or less simultaneously over the whole of Europe and North America. Perhaps the most striking floral change takes place at the entry of the rich Staffordian flora of Kidston (Flora G (Dix)). This marked change has been emphasised by Prof. Trueman and the writer, and it has been suggested that the Westphalian can be divided into lower and upper divisions at this level, and that



the palæontological change is of greater magnitude than that which takes place between the Westphalian and the Stephanian. It is also suggested that it is comparable with the Palæobotanical Break noted by Prof. Gothan between Lower and Upper Namurian.

In South Wales the flora of a part of the Upper Coal Series resembles that of the Lower Stephanian, while the occurrence of certain species in the Keele Series of Warwickshire may possibly indicate that these strata should be correlated with the Upper Stephanian.

Dr. A. RAISTRICK.—*Use of microspores in the correlation of coal seams.*

Two seams of coal have been studied in great detail over a wide area by means of microspore separations: the Trencherbone seam of Lancashire, and the Busty seam of Durham. In the first case, a marked change in the microspore content of the seam in one district is correlated with changes in the structure of the seam and the proportions of its constituent subsections. In Durham, the samples examined are of the Top and Bottom Busty seams, taken at more than fifty localities, the older correlation and naming being accepted for sampling. The microspore analysis shows three distinct areas in the coalfield, the pair of 'Busty' seams giving uniform diagrams over each single area, but the diagrams being different in different areas. The areas of different microspore content coincide approximately with areas of different physical and chemical properties of the coals, and a suggested revision of the Busty correlation is given. Some indication of correlation between different coalfields is discussed.

Dr. J. WEIR.

Lamellibranch zones are easily defined in the Scottish Productive Coal Measures, and some of Wright's subzones can be recognised.

The succession of *affinis*, *pulchra*-maximum, *librata*, and *atra* subzones occurs in Lancashire and in Scottish coalfields and in both areas is terminated by marine deposits—Dukinfield and Skipsey's respectively—that are recognised as equivalent on the basis of their marine faunas. Such corresponding sequences of faunal episodes are valuable in inter-coalfield correlation.

Wright's *pseudorobusta* subzone, at the base of the Middle Coal Measures in Lancashire, is a useful datum in districts where the Lancashire tripartite division is inoperative. In Scotland the base occurs at or near the base of the Coal Measures and, as in Lancashire, it is followed by the *os-lancis* subzone, the *modiolaris* zone generally and finally by the *affinis*-*atra* subzonal succession. That is, in Lancashire terminology, the Scottish Productive Coal Measures are essentially Lower Middle Coal Measures, and the evidence of the shells is substantiated by the plants. As there is no unconformity at the base of the Coal Measures in Scotland it appears legitimate to regard part of the Scottish Millstone Grit, possibly the upper two thirds, as equivalent to Lower Coal Measures and not to Millstone Grit of Lancashire. The meagre lamellibranch fauna of the Scottish Millstone Grit tends to confirm this view.

It is doubtful if the definition of major palæontological subdivisions (of higher rank than zones) would serve any useful purpose. In Scotland, subdivision of the Coal Measures is possible only at Skipsey's Marine Band, a recognised formational boundary, which marks approximately a change in the physical character of the sediments as well as modification of the

non-marine fauna (failure of *Carbonicola* and *Naiadites*; dominance of *Anthraconauta* in the meagre fauna of the Barren Red Measures). The only possible palæontological partition of the Scottish Productive Coal Measures (i.e. between Skipsey's Marine Band and the Millstone Grit) is afforded by mussel zones (and subzones) and by the floral zones recently worked out in South Wales and England.

Dr. D. A. WRAY.

There is a remarkably close similarity in the succession of the lower part of the Coal Measures in each of the Pennine coalfields, and in 1929 the writer published a detailed correlation of these measures based largely on general lithological comparisons. In the Main Productive and higher Coal Measures such data are insufficient, and consequently the faunal and floral successions are of prime importance.

The persistence of very occasional and comparatively thin marine bands over wide areas has been much used, though their value has been considerably enhanced by the studies of the non-marine faunal succession. The striking value of the latter was recently revealed in East Yorkshire, where lithological comparisons failed completely; yet by means of the non-marine shells it was possible to indicate the presence of a complete though greatly attenuated succession of the Main Productive measures as far east as the Trent valley.

The floral succession has not hitherto proved of the same value. In Northern France, however, an intensive study of the succession of plant life by Bertrand and others has led to the establishment of a zonal system of considerable precision and refinement. Its application to the succession in this country by Dr. Dix appears to be yielding promising results.

In 1922, Theissen and his co-workers in America pointed out that individual coal seams had a characteristic spore-content and suggested its employment as a basis of correlation. Attempts have been made to extend this work to Britain, and, if combined with the stratigraphical data already available, it may prove of considerable value in instituting more precise correlations between detached areas of Coal Measures.

Mr. S. G. CLIFT.

The attack by Dr. Wright on the validity of non-marine lamellibranch zones savours of sabotage and is particularly surprising since he is mainly responsible for the further attempted delimitation of subzones, in the Lancashire Measures, based on characteristic 'mussels' which he has named.

Moreover some of these species are known to have a similarly limited range and to occur at corresponding horizons in the zones of the measures of Nottinghamshire and Derbyshire and they maintain their position even in the Scottish fields.

Further investigation in Notts and Derby has shown that the upper and lower limits of the *modiolaris* zone can each be determined within a few feet and evidence of the value of 'mussels' in the zoning of that field will be available at the next meeting of the Association at Nottingham.

Dr. J. O'N. MILLOTT and Mr. J. J. WALKER.

Dr. Raistrick's seam correlation methods have been used in the Fuel Research Coal Survey Laboratories at Sheffield and at Stoke-on-Trent.



Some of the microspore diagrams obtained have proved remarkably similar for samples of the same seam, and different for different seams; but as a rule such results have only confirmed correlations already evident from visual examination of the seams concerned. The salient features of the diagrams are generally due to the two commonest spore types only (*A* and *D*<sub>1</sub>); the former being particularly abundant in the dull bands.

The distribution of the less abundant spore types is considered of greater interest. When sufficiently detailed examinations of each sample are carried out, it is found that some types have restricted time-ranges, which may eventually prove valuable. For example, type *C*<sub>1</sub>, though never very abundant, is found in all seams down to the Haigh Moor in Yorkshire and the Cockshead in Staffordshire, but not below.

The micro-preparations on which the work is based are inevitably of indifferent quality. It is therefore felt that in future work on these lines the statistical aspect of the work should not be too strongly emphasised; attention should be centred rather on the careful definition of species.

Dr. L. SLATER and Mr. J. J. WALKER.

The D.S.I.R. Fuel Research Coal Survey has in many cases obtained useful correlation data through detailed examination of the petrographic composition of the seams concerned. For instance, the Barnsley, Parkgate and Silkstone seams are each banded in a characteristic way; the main bands being recognisable, in pillar samples, by the naked eye.

This banding of seams has also been studied microscopically, by means of thin sections of coal; and it has thus been found that many seams each consist of a series of zones of differing megaspore content. In some cases these zones are of remarkable lateral constancy (e.g. the three above-mentioned seams); in others, the constituent zones are less well-defined, but when sufficiently detailed examination is made useful correlation data may still be obtained from them (e.g. Haigh Moor and Beeston seams).

Most of the megaspore types recorded in this work range throughout the Yorkshire sequence of seams. One, however (*Triletes brasserti*, Stach and Zerndt), is found only in and above the Haigh Moor seam, thereby affording a useful datum line.

So far thin sections of coal have proved the only reliable means of deciding on the presence or absence of a megaspore type; separation methods using Schulze solution have given misleading results.

Mr. G. A. KELLAWAY.

Under the direction of Prof. A. E. Trueman a preliminary investigation has been made of the microspore content of certain South Gloucestershire coals belonging to the Farrington Series. More exhaustive examination may yield further results, but, at present, it would seem that the uniformity in the spore content renders correlation of seams within this series a matter of considerable difficulty. From 75 to 85 per cent. of the spores fall into two categories, subdivisions of which are of doubtful value.

The comparative uniformity of the flora of the upper part of the Westphalian is in strong contrast to the rapid floral changes seen in the Lower Westphalian; the value of microspore analysis as a correlative method may be limited by this factor.

AFTERNOON.

Excursion to Rivington Pike. Leader, Mr. R. C. B. JONES.



### Wednesday, September 16.

Mr. V. E. FUCHS.—*Lake Rudolf: its formation and history* (10.0).

The Lake Rudolf basin was formed by earth movements that began in the late Oligocene and continued well into Pleistocene times. The chief interest of the area lies in the fact that not only do we see there the northern continuation of the Kenya rift fractures, but also ample evidence of the operation of widespread forces of pressure.

The initial fracture cut off the northern extension of the Uganda peneplain, and upon its downthrow side a series of Miocene sediments and volcanics accumulated. These were then asymmetrically folded from east and west towards the axis of the present lake. Accompanied by local thrusting these folds gave rise to the topography of the early Pleistocene lake basin. The deposits formed in it were disturbed by still later movements, which, accompanied by vulcanicity, completed the lake basin in its present form.

To-day the lake does not occupy so large an area as it did because fluctuating but progressive desiccation has lowered its level by more than 300 ft. since Acheulian times. Everywhere its high-water mark is defined by lake beaches containing mammalian and molluscan remains together with the stone implements of early man. Modern conditions indicate that the desiccation of the area still continues.

Mr. W. CAMPBELL SMITH.—*Igneous rocks from Turkana, Kenya Colony* (10.45).

A petrographic study has been made of a large number of rocks collected in the province of Turkana by Mr. Arthur M. Champion. The extrusive rocks include olivine-basalts and basanites from the neighbourhood of the Teleki volcano at the south end of Lake Rudolf, and a series of other lavas comprising soda-rhyolites, pantelleritic trachytes, basalts, phonolites, and nephelinites occupying much of the country west of the lake and as far north as the northern frontier of Kenya Colony. There are some minor intrusions of ijolite, microfoyaite, and sölvbergite.

Prof. H. H. SWINNERTON.—*Saline waters and soils of East Lincolnshire* (11.15).

The coastal flats, known as the Marshlands of East Lincolnshire, were originally reclaimed from salt marsh. It is generally believed that as the result of exposure to percolating rain water the salt is all washed out of the surface layers of such saline silts. This process is, however, dependent for its efficiency upon an adequate supply of freely flowing river water. Near the south end of the Marshland there is an extensive area where such a supply is not available. Here the soil and the rain water which percolates through it into the drains still hold a high content of salt.

REPORTS OF RESEARCH COMMITTEES (11.45).

## SECTION D.—ZOOLOGY.

Thursday, September 10.

PRESIDENTIAL ADDRESS by Dr. J. S. HUXLEY on *Natural Selection and evolutionary progress* (10.0).DISCUSSION on *Selection* (11.0).Dr. TIMOFÉEF-RESSOVSKY.—*Introduction.*Prof. G. D. HALE CARPENTER, M.B.E.—*Entomology and Natural Selection* (11.25).

The following are difficult to explain without Natural Selection :

(1) Mimicry in Uganda of species of the Acraeine genus of butterflies *Bematistes* (= *Planema*) by forms of one species of Nymphaline *Pseudacraea eurytus*. Not only are local species of *Bematistes* mimicked by forms of *eurytus* numerically proportional to their models, but if the protective influence of *Bematistes* is diminished by their scarcity the forms of *eurytus* depart from strict resemblance and intermediates abound. (2) Experiments with a monkey under natural conditions showed that out of 143 species of insects with conspicuous (aposematic) coloration 120 were distasteful, and out of 101 with concealing (procrptic) coloration 83 were edible. Lycid beetles, much mimicked in all tropics, were not eaten even under conditions of considerable hunger : they are typically aposematic. Procrptic weevils and Mantidae were greedily eaten. (3) Adaptations of flowers and insects for mutual benefit. A very peculiar relationship exists between an Australian orchid and an Ichneumon, the male of which, deceived by odour like that of its female, enters a flower backwards and while depositing its spermatozoa on the stigma causes the pollinia to adhere to its abdomen and thus withdraws them.

Dr. C. GORDON.—*Evidence for natural selection from the genetic analysis of free-living populations of Drosophila* (11.40).

The frequency of heterozygosis in free-living populations of *Drosophila* of both sex-linked and autosomal mutants can be determined by appropriate methods of inbreeding. The great bulk of evidence shows a considerable frequency of autosomal recessive mutants and an absence of sex-linked recessives, and dominants. It is clear from the data that sex-linked recessives have been eliminated by natural selection, unless the assumption is made that the mutation rate of autosomal genes is vastly greater than that of sex-linked genes, which is not the case.

Another line of evidence which should be developed further is the direct method of releasing a balanced laboratory population whose genetic constitution is known and estimating the frequency of heterozygosis of the mutant type from time to time. A preliminary experiment which I undertook in 1934 showed that this is possible. The frequency of a mutant gene ebony declined from 0.5 to  $0.110 \pm 0.03$  in the course of one summer. At the present time I am investigating various areas as to their suitability for this type of work.

Mr. F. C. MINNS.—*The experimental approach to sexual-selection* (11.55).

In an animal of a mixed population the possession of particular characteristics may render mating more probable or less. These characteristics will tend accordingly to become more or less common. When two or more varieties occur together and each shows a preference for its own kind ('assortative mating') they are by this means partially isolated. They will therefore tend to evolve on slightly different lines and new species may result.

Quantitative experiments on the banana-fly *Drosophila* have shown assortative mating and other types of sexual selection to occur between the wild type and mutants and also between apparently identical races.

Mr. E. B. FORD.—*Selection in relation to the genic background* (12.10).

Selection can operate only on genotypic variability. This is controlled by genes having multiple effects, and interacting with one another to produce the characters for which they are responsible. They thus form a total gene-complex, alterations within which may affect the operation of any one of its members.

Two types of selection are thus possible. First, that preserving advantageous genes and eliminating disadvantageous ones. Secondly, that tending to alter the *effects* of a gene, but not the gene itself. This is brought about by selection operating on the gene-complex, so that a genetic constitution is spread through the population which tends to bring out the effects of particular genes to the greatest advantage.

In this way, varied evolutionary changes may take place within polymorphic forms, which can yet remain under simple Mendelian control, acting as a switch to determine which group of characters shall be expressed. Fluctuations in numbers allow genes to be tested by selection in different gene-complexes, with some of which they may react in new, and possibly beneficial, ways. Selection acting on the less obvious genic effects may be partly responsible for the recent spread of melanism among the Lepidoptera in industrial areas.

Prof. H. J. MULLER.—*Summary of the discussion* (12.25).

#### AFTERNOON.

Prof. W. J. DAKIN.—*An account of ancient and modern whaling in Australasian seas* (2.15).

At the Plaza Cinema, Manchester Square (4.30):

Exhibition of films by kind permission of Gaumont British Instructional Films, Ltd.:

Hydra.

Obelia.

Nursery Island.

The development of the frog.



Three other films were shown at the same time :

- (1) By Mr. A. G. LOWNDES.—*Chirocephalus*.
- (2) By Dr. P. D. F. MURRAY.—Beating and fibrillation in the chick embryo heart.
- (3) By Mr. C. H. WADDINGTON.—Marine sand animals.

### Friday, September 11.

Prof. C. M. YONGE.—*Egg membranes and egg attachment in the Crustacea* (10.0).

The discovery that the integument of the Decapod Crustacea consists of an inner chitin and an outer cuticle, the latter secreted by tegumental glands, has made possible the elucidation of the nature of the membranes surrounding the egg. The origin and nature of these has been the subject of considerable controversy.

As the egg descends the oviduct a layer of chitin, secreted by the epithelium, is laid down around it. At this period the epithelial cells are greatly elongated and resemble the chitinogenous epithelium at the time when this is secreting chitin for the new integument. The outer membrane is secreted by the tegumental glands which occur in great numbers in the pleopods of the females. These resemble in every way the tegumental glands which secrete the cuticle. The outer shell membrane which they secrete, and which serves to bind the eggs to the pleopods of the female, gives the same reactions as the cuticle.

In *Chirocephalus* the eggs are coated by chitin secreted by the wall of the oviduct, and later a rugose coat, giving the major reactions of cuticle, is added by unicellular uterine glands. In both cases the primary significance of the cuticular layer would appear to be that of protection, but in the Decapoda it also serves for attachment.

Prof. A. C. HARDY.—*Plankton ecology and the hypothesis of Animal Exclusion* (10.30).

A brief review is made of the former evidence of an inverse relationship between the distribution of planktonic plants and animals, and in particular that from the *Discovery* Expedition's South Georgia plankton survey of 1926-27 (Hardy and Gunther, 1935). The hypothesis of Animal Exclusion and evidence in its support are discussed; the exclusion of the animals from the zones of plant concentration is considered to be one in a vertical rather than a horizontal plane, and the inverse distribution seen in plan to be secondarily produced by differing water movements at different levels.

Dr. C. H. MORTIMER.—*Parthenogenesis and bisexual reproduction in the Cladocera* (11.30).

The alternation of parthenogenesis and bisexual reproduction in the Cladocera and its causes were investigated under controlled cultural conditions. Under optimum conditions parthenogenesis could be maintained over a considerable period (indefinitely ?) without signs of depression. Various external factors—low temperature, lack of food, over-population in the culture—could be made to cause the appearance of bisexual reproduction at will. The periodicity of the alternation in nature is therefore

thought to be dependent on periodic environmental changes and not, as Weissmann suggested, on inherent internal rhythms.

Both female- and male-producing parthenogenetic eggs undergo only one maturation division resulting in no reduction in the diploid chromosome number (20 in *Daphnia magna*, 24 in *D. pulex*). The same diploid number was found in the spermatogonia of *D. magna*. Spermatogenesis appeared normal. The mechanism of sex determination appears then to be extra-chromosomal.

Mr. K. R. ALLEN.—*The ecology of young salmon* (12.0).

In the rapid rivers which salmon usually frequent there is no true plankton, and therefore fish living in them must feed either on the bottom or upon objects floating on the surface. As surface food is only available in summer, and is not eaten by salmon in their first year, the main food supply of young salmon is derived from the bottom. Although algæ may be abundant, the salmon, even when very small, feed only upon the fauna. It has been found that there are consistent differences in the relative extent to which different species of food animals are eaten; these differences appear to be correlated with differences in the availability of the food animals to the fish.

Seasonal changes in the type of water inhabited by young salmon have been found to occur. In summer the fish live in comparatively shallow water, but in winter they retire to deep pools and probably lie quietly in sheltered places, only occasionally emerging to feed. There is a check in growth during this time.

Miss W. E. FROST.—*Trout food and river fauna* (12.30).

Work done by him on lakes and rivers in Ireland suggested to the late Mr. R. Southern that they could be divided into two fairly well defined types as regards their brown trout: on the one hand, alkaline waters derived from limestone rocks, where the trout grow rapidly and attain a weight of 2, 3 or more pounds; on the other hand, acid waters derived from non-limestone rocks, where the fish grow slowly and seldom exceed  $\frac{1}{4}$  to  $\frac{1}{2}$  lb. in weight.

In 1929 a biological survey of the river Liffey was begun in order to obtain quantitative and qualitative data concerning the food of brown trout from acid and alkaline waters, and thus throw some light on this problem of widely differing growth rates.

The two stations on the Liffey chosen for detailed investigation were Ballysmuttan, where the water is acid (pH 4.6 to 6.9), and Straffan, where it is alkaline (pH 7.6 to 8.3). Brown trout were captured during all the months of the year, the stomach contents noted, and simultaneously observations on the river fauna were made. The type of food organism taken by the trout varies somewhat with the time of year at both stations, but not so much as would be expected. This variability seems to depend more on the size of the fish, the height and condition of the water, etc., rather than on the season.

The abundance of some of the aquatic animals is to a certain extent reflected in the diet of the trout. At Ballysmuttan Ephemeropterid larvæ are scarce and Perlid larvæ are common: the reverse applies to Straffan. These larvæ are found in corresponding proportions in the stomach contents of the fish from the two places. Certain organisms (fish, crayfish) abundant in the river form but a small part of the trout's food. Trout, both spent and immature fish, with full stomachs, have been taken during the winter.

The differing growth-rate in alkaline and acid waters does not, generally speaking, appear to be due to a food shortage in the latter waters.

## AFTERNOON.

JOINT DISCUSSION with Section H (Anthropology) on *Genetics and Race* (Prof. H. J. FLEURE, F.R.S.; Dr. J. S. HUXLEY; Dr. G. M. MORANT; Prof. A. M. CARR-SAUNDERS; Prof. R. RUGGLES GATES, F.R.S.; Prof. F. A. E. CREW). See p. 458.

**Saturday, September 12.**

Excursion to the Lake District and Wray Castle.

**Monday, September 14.**

DISCUSSION on *The function of the museum in zoology* (10.0).

Dr. D. A. ALLAN.

General museums in Europe divide their material into that illustrative of the Natural Sciences and the remainder illustrative of Archæology and Ethnology. In the first group, as regards both bulk and interest, zoology is of prime importance, as can be seen in any of our larger museums. The material is divided into preserved but unmounted study specimens for the use of experts, and mounted, more or less life-like individuals and groups exhibited for the general public. From the small habitat group has developed the large diorama. Other exhibits include the life history series, the topical show and economic zoology displays. Modern methods of preservation and preparation, together with accurate and artistic taxidermy, have revolutionised exhibits. The problem of the smaller museum, with its restricted space and funds, is whether to concentrate on showing the fauna of the district or to attempt to illustrate general zoology. Museums are the means of teaching popular zoology, and of securing the rejuvenation of our Natural History Societies.

Mr. M. A. C. HINTON.

Prof. W. J. DAKIN.

Dr. A. C. STEPHEN.

The new or projected exhibits of the Royal Scottish Museum may be used as a basis for discussion regarding the kind of exhibit which attracts the visitor. If large enough the zoological museum should certainly contain a good collection of the local fauna, with special stress on any local industry, such as fishing, etc.; a series giving an introduction to classification; a series of biological exhibits and a popular palæontological series. Each hall or series of exhibits should serve as a handbook to the subject in question, that is, should have a consistent story running through it; be as lavishly illustrated as possible (specimens, drawings, etc.) and be adequately described (good and numerous labels).

The exhibits of biology and palæontology can be arranged with general acceptance, but it is open to question whether the extensive systematic collections so often shown should not be reduced and the surplus rearranged to illustrate special points of interest, such as geographical distribution, etc. It is doubtful whether the small museum which has no full



time, or keen amateur, curator fulfils its function unless it can form part of a series of similar institutions supplied with circulating collections from some central organisation.

Mr. J. A. S. STENDALL.

Mr. A. W. BOYD.—*The British Trust for Ornithology ; Swallow Enquiry* (11.30).

Mr. D. LACK.—*The bird census as an ecological method* (12.0).

With the investigation of the ecological principles underlying bird distribution, the vague terms, common, rare, etc., must be replaced by definite numbers. Census work is arduous, and only a limited number of types of bird and environment are suitable for large-scale investigations. For several conspicuous species, breeding censuses have been taken over wide areas, and in various areas the total breeding population of all species has been counted. Some of these censuses have been repeated over a series of years. Winter populations, which are more fluctuating, have been estimated in a few cases.

Census work is providing information on the degree of annual fluctuations in breeding populations, on the relation between breeding and non-breeding individuals, on the size of clutch and nesting mortality, on the changes in bird population with a changing habitat, on the size and degree of uniformity of defended breeding territories, and other problems. Progress is being made, but the study of the factors influencing bird distribution is still in its infancy.

Dr. W. K. SPENCER, F.R.S.—*Function and adaptation in early Echinodermata* (12.30).

The Cambrian and Ordovician rocks contain some beds composed of very fine mud and containing a fauna which represents old sea bottoms. The fine sediment has preserved extremely good detail of the original animals, and reconstruction can be made not only of the form but of habit. Short accounts will be given (a) of *Stromatocystis*, one of the oldest known fossils which lived in intertidal waters—this form is not ancestral to the Eleutherozoa, as suggested by various writers, but a highly specialised ciliary feeder: comparisons can be made which suggest that *Stromatocystis* and other Edrioasteroids are related to the Blastoidea; (b) of some Cystoids in which the plates of the theca had important functions in respiration, there being a circulatory system within the plates themselves; (c) of *Cothurnocystis*, which turned itself over on its side, like the flatfish of to-day.

#### AFTERNOON.

JOINT DISCUSSION with Section M (Agriculture) on *The poultry industry* (Section D room) (2.15).

Mr. W. HAMNETT.—*The poultry industry and its problems.*

The main problems affecting the poultry industry are concerned with (1) breeding, (2) nutrition, (3) disease. It should be realised that the workers on the nutritional and disease side are not expected to work miracles on birds that have been bred without regard to constitutional vigour. Low

fertility is a cause of much loss amongst breeders of Utility White Wyandottes, and fertility is often stated to be as low as 50 per cent. average over the hatching period, whilst with other heavy breeds kept under identical conditions the fertility is 85–90 per cent. Similarly, information is required as to the inheritance of fecundity and as to why the progeny of apparently healthy vigorous birds are often lacking in stamina and vitality. On the nutritional side it may be noted that feeding-stuffs are responsible for about 60 per cent. of the costs of production. It is essential, therefore, that with changing market prices, the poultry farmer should have information as to the interchangeability of feeding-stuffs from the point of view of their nutritive value and productive capacity. On the disease side, cures are wanted for occidiosis and worm infestation generally, and for paralysis in its various forms, and preventatives for cholera, fowl plague, and laryngo-tracheitis.

Dr. A. W. GREENWOOD.—*Breeding problems* (2.30).

A discussion of observations made on a series of Brown Leghorn fowls at the Institute of Animal Genetics, with particular reference to economic productivity in respect of egg production, over a number of years. The influence of environmental agencies and the possible genetic implications are reviewed.

Mr. E. T. HALNAN.—*Nutrition problems* (2.45).

In research work on problems of poultry nutrition, two methods of attack are available: a short range method in which an answer to a specific point of practical interest is sought, and a long range method in which the basic principles upon which feeding systems are dependent are studied. Each method has a definite place in any scheme of research, and examples are given to show that, by careful planning on the part of the research worker, long range methods of research may be so designed as to yield results of practical value to the poultry industry within a reasonably short period of time.

The evolution of a flexible system of feeding, whereby the poultry keeper will be enabled to exercise considerable freedom of choice in the selection of alternative feeding stuffs, is shown to depend upon the acquisition of a large body of knowledge attainable only by work of the long range type; in particular, knowledge of a quantitative character.

The relation of nutrition to disease is briefly discussed, and the limited influence of nutrition on the control of disease indicated.

Dr. E. L. TAYLOR.—*The economic and disease aspect of parasitic worm infection in poultry* (3.0).

For purposes of this discussion the parasitic worms of poultry are divided into those which are usually associated with disease and those which are not, 'definite pathogens' and 'indefinite pathogens.' The definite pathogens are represented in this country by the gapeworm of chickens and the gizzard worm of geese; at the present time they are causing comparatively little trouble, but the gapeworm may become a major problem should more extensive systems of rearing become popular.

A few members of the group of indefinite pathogens are of very frequent occurrence in healthy birds; as yet we are quite unable to determine when these worms are causing disease and when not, and opinion is widely

divergent on their importance to the poultry industry. What little work has been done, however, suggests that light or moderate infestations cause no discernible injury, although heavy ones may. Treatment of whole flocks with drugs is, therefore, unwarranted unless an unusually heavy infestation is known to be present.

Until more satisfactory experimental evidence is forthcoming on the pathogenicity of these parasites and the significance of multiple parasitism, the economic importance of these widely distributed parasitic worms will remain a matter for conjecture.

Other speakers, including Mr. A. J. MACDONALD, Mr. J. WILSON, and Dr. A. L. ROMANOFF.

## Tuesday, September 15.

### DISCUSSION on *Morphogenesis* (10.0).

Mr. C. H. WADDINGTON.—*Organisers and their limitations.*

An embryonic organ has, at any given time, a definite shape, and as time progresses the shape alters in a determinate way into a new shape of greater complexity. The influences which bring about these changes of shape must themselves be arranged in an orderly way in space, and the whole set of forces which control the shape of an organ may be spoken of as the field-forces of that organ. The paper will discuss the general concept of embryonic fields, with particular reference to the field-forces of the neural plate of the Amphibia and the way in which they are dependent on the underlying mesoderm.

Dr. P. D. F. MURRAY.—*Morphogenetic fields and self-differentiating mosaics* (10.30).

Morphogenetic fields are characterised by their integration as units, by their ability to incorporate indifferent material within themselves, and by their ability to regenerate parts of themselves. In the development of the chick embryo jaw the determination, or evocation, of tissues occurs in three separate regions, presumably by three acts of evocation. The loci of determination are not fields but areas, though they may constitute a field together with the organiser responsible for their evocation. In later histogenesis, field phenomena are less easily recognisable. In its morphogenesis, the chick embryo limb-bud is a mosaic, without obvious relations of dominance and subordination between its parts, and almost lacking in the other field characters. Nevertheless, it is probable that some regeneration and regulation may occur, and phenomena characteristic of fields are recognisable in joint formation. Evocation is the event which occurs in the determination of cells to form kinds of tissue, the first stage in histogenesis. Individuation is the integration of determined tissue so that the self-differentiating mosaic is brought into existence, and the parts of the organism concerned in both processes may constitute fields because of the relations of dominance and subordination which exist between them.

Prof. E. A. SPAUL.—*Endocrines and morphogenesis* (11.0).



Dr. J. NEEDHAM.—*Chemical interpretation of fields* (11.30).

Although the time has hardly yet come when it is possible to make much progress in the investigation of the chemical basis of morphogenetic fields, some preliminary thinking is not without interest. That three-dimensional co-ordinate systems have an objective existence in the form of gradient nets within developing embryos now hardly admits of doubt, but the evidence that these gradients are of metabolic rate is not convincing. Diffusion gradients of active substances, that is to say, chemical molecules which exert some orienting action upon protein molecules, are conceptually more helpful. It should, however, be remembered that gradients in a morphological field may also be gradients of varying degrees of randomness in molecular orientation, the active centre being itself stationary. We need to know a great deal more about the shapes and coherence properties of protein molecules, and about the relation between histological structure and protein fibre arrangement. Finally the morphogenetic field must be constructed of qualitatively, not merely quantitatively, varying differences along its axes.

Prof. E. G. CONKLIN.—*Summary of the Discussion* (12.0).

#### AFTERNOON.

Mr. G. E. H. FOXON.—*Orientation to gravity in Crustacea* (2.15).

Orientation to gravity is of importance to various groups of Crustacea for different reasons. In the higher Crustacea a definite organ of balance (statocyst) is commonly found, but in certain cases, particularly in the lower Crustacea and the larvæ of the higher Crustacea no such organ is present. In such cases orientation to light is usually so dominating a factor that in the presence of light response to gravity disappears; if, however, such creatures are observed in red light (to which they do not appear to respond) orientation to gravity is seen to exist.

Experiments have shown that it is possible to make a series covering the various methods of orientation to gravity thus:

- (1) Orientation to gravity entirely mechanical: example *Chirocephalus*.
- (2) Orientation to gravity mechanical but depends on the normal activities of the animal being maintained: example *Daphnia*.
- (3) Orientation to gravity the result of muscular action, but no special sense organ present: example *the larvæ of many Brachyura*.
- (4) Orientation to gravity the result of muscular action, a special sense organ present: example *adult Brachyura*.

Mr. A. G. LOWNDES.—*The term 'gnathobase'* (2.45).

In Lankester's classical essay (1881) on the appendages of *Apus* he defines the proximal endite of the trunk limb as a 'gnathobase,' stating that 'it is a jaw process' and 'clearly has the function of assisting, by means of apposition to its fellow of the opposite side, in seizing and moving particles which may be introduced into the mouth.'

Lankester's use of the term has been severely criticised on three separate occasions by Prof. Graham Cannon, 1927, 1928 and 1933, who together with Dr. Manton (1927) pointed out that in the Anostraca the proximal setæ of the basal endite are covered over medially by setæ from the limb in front so that they cannot transport food towards the mouth and certainly do not work in apposition to their fellows on the opposite side.

*Chirocephalus* abounds in the Marlborough district and we have had ample opportunity of investigating this point. I have also filmed completely the working of these gnathobases, and I maintain that they can and do work in apposition and function in the manner indicated by Sir Ray Lankester.

The film shows these gnathobases on the one side working in apposition with those of the other side.

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Mr. J. A. MOY-THOMAS.—*The evolution of Elasmobranchs* (3.0).

The Cladoselachii and Ctenacanthus are the earliest and most primitive Elasmobranchs, and it is almost certain that the former are closely related to the ancestral form.

It is fairly certain that three main lines of evolution occurred, the Pleuracanthus, a group leading to the Holocephali and a group leading to all modern sharks.

The group leading to the Holocephali can be distinguished by the microscopic structure of the teeth and, where known, the anatomy of the skull. The Pleuracanthus form a compact group with characteristic median and pectoral fins. The third group seems to have arisen from the Ctenacanthus which are more specialised than the Cladoselachii. It is to this group that the majority of the post-palæozoic sharks belong.

Visit to Lytham Mussel Cleaning Station.

## SECTION E.—GEOGRAPHY.

Thursday, September 10.

PRESIDENTIAL ADDRESS by Brigadier H. S. L. WINTERBOTHAM, C.B., C.M.G., on *The mapping of the Colonial Empire* (10.0).

Lt.-Col. F. J. SALMON.—*The modern geography of Palestine* (11.15).

The paper describes the striking alterations that are affecting large areas in Palestine, how development is being assisted by the new land regime, and how the changes are being illustrated on maps. The old and new systems of land tenure and the activities of the Department of Lands and Surveys are briefly explained. Communications illustrated by the motor map and the map of Roman Palestine showing old and new routes. Short account of the water-resources survey, water supply, drainage and forestry. The development of the towns illustrated with maps, including a new survey of the ' old city ' of Jerusalem. Modern surveys and maps in some detail, with

an account of the projection, grid, scale, arrangement of sheets, conventional signs, etc. Explanation of the reasons for their adoption. The frequent failure to recognise a good survey as an important national monument. The need for more education in the use of maps.

Sir ALBERT E. KITSON, C.M.G., C.B.E.—*The importance of topographic maps to mining* (12.0).

Topographic maps of a country are of great assistance in its development, especially if it is more or less in its natural condition, is thickly forested, and has varied and high relief.

Broadly speaking, mining embraces two stages: (1) prospecting the country for mineral deposits; and (2) initial development and underground mining of them.

The search for mineral deposits occurring detritally in the gravels of streams, and as lodes and reefs in the rocks, with lateral extensions of such deposits, is greatly aided by knowing the courses of streams and the trend of hills and ridges, with their interrelations.

Economic mining of mineral deposits is dependent upon various factors, such as: (a) configuration, affecting routes for transport of heavy mining and milling machinery; (b) a good supply of timber for underground mining and for fuel for motive power; (c) water power, from waterfalls or dams in suitable gorges of good streams; and (d) locations for mining and milling plants. Other factors exist, but cannot be mentioned in this limited summary.

Good topographic maps show the natural features indicated, and others besides. Without such maps these features have to be ascertained locally, often with much delay to development of mining operations.

Air survey maps also give much valuable information of, *inter alia*, the topography, geology and mining operations. They are thus of great value, especially in the early stages of ground surveys, and they can be rapidly and cheaply produced.

#### AFTERNOON.

Mr. W. SMITH.—*The agricultural geography of the Fylde* (2.0).

The paper consists of two parts. The first is a general analysis of the agricultural geography of the Fylde and an assessment of the relative importance of the several departments of Fylde farming in respect of the acreage they appropriate. The second is a more detailed analysis of dairying, the major objective of Fylde agriculture.

The Fylde is shown to be an area of mixed farming, but with permanent grass dominant and with arable recessive. In 1934, of the total in crops and grass, 21.1 per cent. was in arable and 78.9 per cent. in permanent grass. The clay loams of the upper boulder clay are largely in grass and the arable is mostly on the lighter soils of the silt, peat and blown sand. Of the arable about half produces stock food for consumption on the farm.

Live stock are thus the objective of 90 per cent. of the acreage. Dairying is the chief objective of this live stock farming. The Fylde is neither a feeding nor a store raising district. The proximity of a market for milk in the coast towns and in industrial Lancashire makes dairying the more profitable enterprise. Other stock are kept in lesser proportions.

The results are described of a method, which the author has elaborated, of constructing a grazing index for the Fylde in early June based on the management followed in the district. The density of stocking in early June



works out at 0.92 of a grazing unit per acre, a grazing unit being a cow in milk yielding two gallons daily and obtaining her total requirements from grazing. The grazing index is then used to calculate the grazing acreage which each class of stock appropriates and the predominance of the dairy herd is demonstrated.

The detailed analysis of dairying considers the effect of environmental and economic factors. The environmental factor is chiefly a matter of grass. The approximate quality of Fylde pastures is defined and the monthly variation of grass growth described. The economic factor for milk is shown to vary as between those farms which produce for the seaside market with its maximum demand in July, August and September, those farms which supply the level market of industrial South Lancashire, and the farmhouse cheese-makers with their maximum production of milk during the flush of grass in May and June. A curve is shown of monthly production for the Fylde as a whole, the sample from which the curve was constructed covering nearly a half of the total cow population of the district. Milk production rises in May and June with the flush of grass and is maintained in July to September owing to the seaside demand, although various means have to be adopted to maintain production after June, when grass is becoming less plentiful and less nutritious.

Finally, the distinction in geographical distribution, in seasonal rhythm of production and in size of farm between producer-retailers, farmers selling milk wholesale and farmhouse cheese-makers is demonstrated.

Mr. R. KAY GRESSWELL.—*Geomorphology of the south-west Lancashire coast-line* (2.45).

The great tidal range, the total absence of shingle, and the great area of blown sand cause a number of shore-line processes to occur in an extreme form. Between Southport and Formby the profile across the beach resembles a number of waves, having a wave-length of about 500 ft. and an amplitude of 3–5 ft. These lie mutually parallel but inclined away from the shore-line northwards, in an attempt to face the dominant waves. The crests of these undulations are named 'fulls,' and the troughs 'lows.' They are developed in a modified form on the other parts of this coast-line. There was rapid accretion at Formby Point during the last century, but erosion is now occurring, although accretion continues northward. Between Hightown and Blundellsands, the river Alt, now diverted by a dam, meandered until 1936 for  $2\frac{1}{2}$  miles southwards along the foreshore, indirectly causing rapid and serious erosion at Blundellsands. It is concluded from a study (1) of the wind directions, (2) of the gale directions, (3) of the direction of maximum length of fetch, and (4) of the lie of the fulls and lows, that foreshore drifting occurs away from Formby Point in both directions. This at once provides a single explanation for the apparently mutually contradictory phenomena occurring on this coast-line.

Dr. W. O. HENDERSON.—*The problems of Lancashire's cotton supply* (3.30).

For over a century the bulk of Lancashire's cotton has come from the U.S.A. There is no guarantee that supplies from this source will be adequate in the future. The American Government has deliberately reduced the size of the cotton crop, and there is the danger of a bad harvest owing to climatic conditions or to the ravages of the boll weevil. An increasing proportion of the crop is being used by American cotton factories. Lancashire's dependence upon a single source of supply for so much of

her raw material may appear surprising, since cotton can be produced on a commercial scale in many tropical and subtropical regions. But there are serious hindrances to large-scale production, such as dangers from drought and various forms of disease, as well as lack of labour and communications. Other crops may be more profitable than cotton, and local mills may absorb the bulk of the crop. Cotton-growing has been fostered in many regions, particularly in the Empire and in Egypt. In India the harvest is over 2,000 million lbs., but the quality is not suited to Lancashire's needs and only a small proportion of the crop is used in English mills.

### Friday, September 11.

Mr. O. G. S. CRAWFORD.—*The archaeological work of the Ordnance Survey* (10.0).

Major R. L. BROWN.—*Maps and road communication* (10.45).

When the motor car was first introduced it ran upon the existing roads. Those roads, designed for other purposes, were unsuitable; and unsuitable roads mean needlessly high operating cost for every vehicle travelling on them. Once established upon uneconomical alignments, alteration has been difficult and costly. In Great Britain our initial error was not due to the lack of topographical information, for our country was the best mapped in the world.

In the colonial Empire the situation is the reverse. Obstacles to economical alignment are few, but topographical information is lacking.

Without a properly contoured topographical map the engineer cannot choose the best alignments upon which to make his detailed location surveys. His only recourse is to make his own map. In unmapped countries all engineers and others engaged on geology, railways, flood control, administration, and many other activities are forced to the same unsatisfactory expedient. With the timely supply of good topographical maps, the saving on but a few of these activities would be more than enough to map the whole Empire.

A co-ordinated plan for the topographic mapping of the Empire is an urgent need. Without maps development must continue to be handicapped at every turn, waste condoned and the future mortgaged.

Major M. HOTINE.—*A grid system for Ordnance Survey maps* (11.30).

Present system of projecting and indexing Ordnance Survey 1/2,500 large-scale plans on county meridians.

Proposal to recast the large-scale survey on a single meridian as a continuous national series, without discontinuity at county boundaries, to meet modern requirements.

The problem of indexing and joining 52,000 sheets of a single series indicates cutting sheet lines along the rectangular co-ordinate lines of the map projection. Internal division of the plan by a system of squares (or 'grid'), whose sides also coincide with the rectangular co-ordinate lines, provides a ready means of plotting positions from surveyed co-ordinates, the possibility of adding extra surveyed material on revision without depreciating the basic accuracy of the plan, and a ready means of referring to the position of points by means of their 'grid' co-ordinates.

The desirability of utilising the same grid system on maps of all scales: to facilitate the compilation of smaller scale maps from gridded larger



scales ; to make any gridded map a comprehensive topographic index to any larger-scale series ; to ensure that the grid co-ordinate reference of a point shall be unique without specifying also the scale or series. Necessity for decimal subdivision of the grid to facilitate plotting and to allow for more precise referencing on the larger scales (up to the natural scale of the basic triangulation) by simple addition of extra co-ordinate figures.

The optimum size of grid square to allow easy decimal subdivision by eye ; to reduce to workable limits the effect of paper distortion ; yet not to obscure the detail of the map.

Choice of co-ordinate unit for the grid—the link, foot, yard or metre ?—in view of the foregoing considerations, and in addition to ensure permanence, to result in brief unit references, and to facilitate use for surveys of different types. Change in the nature of the problem introduced by the proposal to grid maps on all scales (particularly the basic 1/2,500 scale) in the same system.

Mr. G. H. KIMBLE.—*The influence of Church and State on Renaissance cartography* (12.15).

Renaissance cartography bears testimony to two main kinds of influence : (a) traditional and (b) political. The influence of tradition—mainly ecclesiastical—is seen in : (1) The persistence of erroneous ideas in the face of new knowledge. (2) The distortion of new facts to fit old theories. (3) The conflict of loyalties, e.g. classical versus ecclesiastical scholarship. (4) The portrayal of myths and legends. (5) The reluctance to accept facts incompatible with accredited theories.

Under such a regime maps could have no real value. Hence the need for a practical map-science and the rise of the Portolan Chart. Undeterred, however, the schoolmen began 'harmonising' the old and the new.

With the beginning of Portuguese overseas enterprise, cartography became subjected to a new influence—political. Successive Portuguese governments maintained a 'conspiracy of silence' whereby they endeavoured to suppress information calculated to damage their foreign interests. This is attested by : (1) The reticence of official chroniclers concerning the course of discovery after 1450. (2) The entire absence of Portuguese maps in the fifteenth century and their scarceness in the early sixteenth century. (3) The indifferent quality of certain fifteenth-century maps purporting to give the African discoveries. (4) The time-lag between discovery and mapping.

#### AFTERNOON.

Excursion to Fylde farms (2.0).

Lecture to school children by Brigadier H. S. L. WINTERBOTHAM, C.B., C.M.G., D.S.O., on *How maps are made* (3.0).

### Saturday, September 12.

Excursion to Fleetwood and the Lancashire coast (9.0).

### Sunday, September 13.

Excursion to Ribbleshead and Pennine Dales (9.0).



### Monday, September 14.

Dr. VAUGHAN CORNISH.—*National parks and the preservation of nature in England* (10.0).

The hand of man has added much to the beauty of the landscape, both by the cultivation of nature and by architectural construction. But in order that the scenery of civilisation may be satisfying to the æsthetic sense there must be a suitable relation between the works of man and their natural setting and background, and in a country so densely peopled as England there is a serious risk of the scenic environment becoming unduly artificial. In fact, in the industrial towns which grew up in the nineteenth century nature was practically expelled and the townsman lived in a mechanical desert.

The recent Town and Country Planning Act has given local authorities extensive powers for preserving rural and restoring urban amenities. The tasks involved are extremely various, and in many cases can only be successfully accomplished in consultation not only with members of the architectural profession but with specialists in many branches of natural science. This is particularly the case in regard to the preservation of rare species of plants and animals. The archæologist must also be called in to advise on matters relating to historic and prehistoric monuments.

In the present paper the attention of local authorities will be drawn to the societies and institutions (many of them affiliated to the British Association) in conjunction with which it is desirable that local authorities should draw up their planning schemes. The author goes on to point out that for the preservation of an adequate background of nature in England something more is needed than can be achieved by the provisions of the Town and Country Planning Act—namely, the reservation of several large areas as National Parks. Neither the best choice of areas nor their proper administration can be ensured except under a National Authority specially constituted.

In fact the time has come for the establishment of a Board of Scenery, on which the learned societies should be represented, charged with the administration of national parks and the supervision of planning schemes not only of local authorities but also of Government departments. The latter are specially in need of co-ordination and control in the interests of scenic amenity.

Prof. W. H. HOBBS.—*The physical solution of some vexed problems of discovery within the polar regions* (10.45).

Peculiar to the polar regions is a frequent condition of major inversion within the lower fifteen hundred metres of the troposphere, which has now been confirmed by many balloon investigations. This inversion and the freedom of these air layers from dust or moisture accounts for an extreme visibility and a looming, *superior* mirage, sufficient to bring into view objects which are far below the natural horizon. The distance at which elevated features may at such times be viewed is sometimes in excess of 200 geographical miles. By this is explained the astonishing underestimates of distance which have been made by well-known explorers, and the fact that land which they had mapped has been so often sailed over by later explorers. Critical examples of this from the major polar expeditions are cited, and a probable explanation is furnished for a puzzling problem in polar exploration still unsolved.

Prof. G. D. HALE CARPENTER.—*A journey round the Okavango swamp, Ngamiland* (11.30).

Dr. W. BOWIE.—*The mapping of the United States of America* (12.15).

#### AFTERNOON.

Mr. W. G. EAST.—*The Severn waterway in the eighteenth and nineteenth centuries* (2.0).

A brief examination of the geography of the Severn waterway with special reference to the centuries of its greatest importance. Although it was reckoned navigable, for craft of different draughts, as far up as Welshpool, and although no improvements were made until the 1840's, the Severn waterway suffered from many physical defects. A close study of (1) the regime of the river, (2) its profile, and (3) its tidal conditions, explains the differential possibilities for navigation along different parts of its course. Between Longney and Sharpness Point (below Gloucester), physical factors prevented access to and from Gloucester except during spring tides. Hence the need for, and utility of, the Berkeley Ship Canal (1827), which revived the trade of Gloucester, the estuary-head port. Between Gloucester and Worcester (to which spring tides reached) the waterway was relatively good for barges and trows; between Worcester and Bewdley many shallows were found, and farther upstream shoals and rapids were very common. Further, navigation above Gloucester was very irregular, owing to periods of low water and floods. In the late eighteenth century, when canals were cut to the Severn, it became imperative to survey and improve this 'very imperfect' waterway.

Mrs. J. THOMAS.—*The Duke of Bridgewater and the canal era* (2.45).

Packhorse and river transport in the early eighteenth century were incapable of keeping pace with expanding industry and commerce, and despite the efforts of turnpike trustees, the roadways could not cope with the increase of vehicular traffic. The reaction of transport changes on commodity prices was especially evident in the case of coal and bulky raw materials. Having decided to construct canals for the cheaper transport of coal to his Lancashire customers, the Duke of Bridgewater enlisted the services of James Brindley for their construction.

Schemes contemplated to link up Manchester and Liverpool were soon mooted.

The various Acts granting statutory powers to the Duke to construct canals will be considered together with some of the more important engineering problems, e.g. that of crossing the river Irwell, which was solved by making the Barton Aqueduct. His canals were constructed in Lancashire and other counties and soon the ports of London, Liverpool, Bristol and Hull were linked up by inland waterways.

Speculation led to a 'canal mania.'

The paper considers the effects of the amalgamation of canal companies on road and river transport and in turn the effect on canals of railway and road transport.

## Tuesday, September 15.

Mr. S. H. BEAVER.—*The distribution of population in Bulgaria* (10.0).

A population map of Bulgaria, scale 1:600,000, on Sten de Geer's unit dot principle, based on the 1934 census, was exhibited.

The bulk of the population is Bulgarian, but important Turkish groups exist in the south-east and north-east. Pomaks (Islamised Bulgarians) and semi-nomadic Vlachs are most numerous in the western Rhodopes; on the east coast are numerous Greek communities, and on the northern frontier some Romanian groups.

Population density is greatest on the northern platform and in the Maritza basin, and least on the forested mountains—the Balkans, Anti-Balkans, Rila, Pirin and western Rhodopes. Density is low, too, in the dry 'Mediterranean' region of the south-west (Struma valley) and along the southern frontier in the eastern Rhodopes and Istrandja Dag.

Village types differ from region to region. On the northern platform are large nucleated villages (population 3,000–4,000) in the valley bottoms, leaving the plateau itself almost bare. In the Maritza plain and the sub-Balkan basins there is an even spread of smaller villages, with towns at route foci. The villages (*kolibi*) of the mountain regions are composed of dispersed houses. The Arda basin (eastern Rhodopes) is the largest area exhibiting this type, but the Balkan range and the western plateau (High Bulgaria or Bulgarian Macedonia) have similar settlement, the latter also having market towns in the several agricultural basins.

The larger towns are mainly market centres the importance of which has been increased by the railway (e.g. Gorna Orehovitza, Stara Zagora, Pleven) or by water transport (e.g. the river port of Russe and the Black Sea ports of Varna and Burgas). Industrialisation, except in Sofia and Plovdiv, is feebly developed, but Sofia is growing a suburban-industrial fringe.

Miss H. G. WANKLYN.—*The Turkish ports* (10.45).

The end of the Sultanate in Turkey signified also a sharp decline in foreign control over Turkish industry and trade. Since 1923, the economic programme has been organised almost entirely by Turks. Three distinct influences have marked especially the development of the Turkish ports: (a) the deportation of the Greek and Armenian populations, mainly from coasts of Asia Minor, (b) the active Turkish acceptance of the prevailing spirit of economic nationalism and (c) the rapid progress of rail construction in eastern Turkey, which by distributing trade amongst various smaller centres has weakened the old concentration on Constantinople, Smyrna and Trebizond.

The traditional military instincts of the Turks are apparent in the planning of the new railways, which are designed primarily to meet modern strategic needs, and only in the second place to increase commercial activity. There has been, however, a departure from the old east and west running trade routes to establish rail connection north and south between Sivas and Samsun and in the mountainous south-eastern region, thus stimulating the ports of Samsun and Mersin. Though military requirements have led to the traversing by railways of formidable mountain ranges, currency restrictions are hampering the schemes for harbour dredging and construction, to which the geographical obstacles are comparatively mild.



Miss D. M. DOVETON.—*Human geography of Swaziland* (11.30).

Extreme variations in geology, relief, climate and vegetation are characteristic of Swaziland. These variations are reflected in the development of the territory. Its possibilities as a ranching country, for both cattle and sheep, and its mineral wealth, influenced European interest in the Protectorate as early as 1875. To-day the agricultural possibilities include the production of maize, cotton, tobacco and citrus fruit.

The Swazis, who have inhabited the region for about one hundred and fifty years, are mainly herdsmen. To-day, they possess only one-third of their country. The population density of the Swazis is thirty-eight, while that of the Europeans is four persons to the square mile.

There are no railways in Swaziland, and the difficulties encountered in marketing produce in the Union retard progress. Since the Union is the natural outlet for Swaziland, the embargo on cattle, the main asset of both Swazis and Europeans, is ruining the country.

So long as Swaziland remains independent of the Union, and the British Government is unable to protect it against embargoes, the future of the Protectorate is desperate.

FINAL REPORT OF THE COMMITTEE ON *The soils survey of the British Empire* (12.15).

AFTERNOON.

### Wednesday, September 16.

Mr. J. ANDREWS.—*Land utilisation in Australia* (9.30).

The study of land utilisation in Australia might be expected to throw light on theoretical questions of the sequence of land use in a new country. The general theory of such sequence postulates growing intensification from extensive utilisations to intensive and diversified utilisations in response to the stimuli of increasing population and capitalisation. Each successive utilisation is said to establish itself in its optimum areas where returns show the greatest margin over productive cost.

The theoretical position, however, has been complicated by governmental stimulation of settlement and production, and, while the theory has been the basis of the policy adopted, the sequences have not been worked out in practice along the lines suggested by theoretical considerations. The most important aspect, therefore, is the problem of how intensification may be brought about under a policy of executive control. The growth of the more important rural industries is reviewed in this light, and from the point of view of production for an export market. The situation is now radically different from that in which former expansion took place.

The possibilities for expansion in primary industries are considerable, but there are clear limits to the markets available. Stimulation of settlement must be carefully regulated to the marketing prospects and a necessary corollary of such stimulation is control of production and disposal. The paper suggests certain changes in administration and policy to meet the new situation.

Dr. A. RAISTRICK.—*Study of a Pennine Dales parish—Linton-in-Craven* (10.15).

The parish of Linton-in-Craven includes the four ancient townships of Linton, Threshfield, Grassington, and Hebden, in upper Wharfedale, and

offers a very complete picture of social and economic development in the 'Dales.' Within the parish there are over 200 acres of prehistoric lynched area, the site of a well-developed pastoral community life in the pre-Roman period. The Saxon economy is clearly revealed in the strip lynchet field systems and the Domesday survey. The agriculture was continued under monastic granges, and the area developed as sheep farm. In the fifteenth century, lead mining, which had been present under the Romans, became a staple industry, and developed rapidly to the maximum occupation of the area, with the addition in the nineteenth century of coal mining. The nineteenth century saw the change of farming to dairy produce, related to the market at Skipton, with a post-war change to stock raising. The mining industry ceased before 1900, but its place was partly taken by the development of large scale quarrying mainly for production of lime. A smaller and fairly recent industry is the weaving of cotton and cotton-silk fabrics. The relief varies between 600 ft. and 2,000 ft. O.D., and the country is fairly evenly divided between the Carboniferous Limestone and Millstone Grit formations.

Miss D. SYLVESTER.—*Hill villages in England* (11.0).

The two major provinces of hill villages in England are the Palæozoic Uplands region of the north and west and the Scarplands of the south-east. In the first, villages generally occupy more impressive sites which are characteristically at a disadvantage for modern agriculture and transport. But in the south-east the hill village is still normally a convenient agricultural centre for the relatively fertile, lower and more level uplands of this province. Hill villages are most densely distributed in Devon and Cornwall, the central Oolitic and Cretaceous areas and Northern England, north of a line from Flamborough to St. Bees; absent above 1,000 ft.; rare in the plains of eastern England, the southern chalk escarpments and in western and midland regions which were forested or marshy in the pre-Norman period. Hill settlement seeks dry, open and easily defensible sites, and hill-colonisation occurred periodically from Neolithic to Norman times. The north-west province, with strong Celtic traditions, was scarcely touched by the Anglo-Saxon except in Northumbria. The hill villages of the south-east are broadly complementary in distribution to the early Anglo-Saxon burials. Some pre-Saxon cultural distributions show significant but more difficult correlations. Pre-Saxon hill settlements were rarely continued *in situ*. In many regions there was migration to lower hill sites; in others hill settlement was abandoned throughout whole districts.

## SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

Thursday, September 10.

Mr. H. SMITH.—*The changing structure of retail trade* (10.0).

1. Altering structure of retail trade. Phases of change :

(a) Extensions of trading based on large-scale organisation, i.e. multiple shops and department stores.

- (b) Changes in the number of retail outlets, due to special post-war economic conditions, to inter-regional and inter-urban changes in the distribution of population, and to changes in demand, all these being conditioned by the incursion upon 'private' firm business of the multiple shop and department store.
- (c) The progress of co-operative trading.
- (d) Growing importance of the branded and price-maintained article. This may alter adversely the optimum scale of operations for a business, and tends to minimise the skill required for any form of retail trading when it prevails.
- (e) The growth of road transport, altering the habits of purchasers, changing the economic advantages of relative location to the retailer, and providing a method of delivery which is ubiquitous, but expensive.

2. If one can make the assumption that retailing is in any way homogeneous one key to the problem of where to seek in detail for criteria of change may be provided by investigating the trend of the total cost of retailing.

3. If the growing costs of retail distribution are due to 'imperfect competition,' then the reckoning of the total number of retail outlets is no clue to the extent to which the retail market is becoming more or less perfect. It may be getting less monopolistic when numbers are dwindling, or more so when they are growing.

#### 4. Conclusions.

Mr. GEORGE DARLING.—*The economics of co-operative trading* (11.30).

The co-operative movement in Great Britain is a consumers' trading movement possessing certain unique features which distinguish it from other types of commercial enterprise. The movement consists of 1,150 local distributive societies in which the 7,500,000 members (representing nearly 6,000,000 families) are enrolled, and which cover nearly the whole of the country with a network of shops and services. These local retail societies collectively own and control the two wholesale societies from which they obtain most of their supplies. The wholesale societies have nearly 200 manufacturing plants, in addition to their importing, merchanting, banking, insurance, advertising and other services.

The size and methods of operation of a local distributive society are closely correlated to the size and character of the population it serves. There are therefore local differences in the services provided by these societies. The majority of them are small, each numbering only a few hundred members, and providing a very limited range of services. At the other extreme are a few societies each with more than 100,000 members, operating departmental stores and numerous branch shops. Societies of all possible sizes and many varieties of services are found between these two extremes.

While the consumers co-operative movement has many unique features and exists as 'a state within the State,' it has been influenced by the post-war changes in distribution. Retailing costs have increased; delivery services have had to be established; branch shops have been closed and trade concentrated from new big stores in recognised shopping centres; and substantial improvements have been made in shop architecture and shopping services.

It is difficult to compare the efficiency of co-operative shops with other types of retail stores owing to the inadequacy of the statistics of distribution.



Co-operative costs appear to be lower than those of department and chain stores, the average costs of co-operative retailing being 15 per cent. of sales. Profits are equal to 10 per cent. of sales, and are distributed as rebates on purchases; £22,000,000 were returned to customers in this manner in 1935. This device of returning profits to customers is the attraction which co-operative trading has for its huge membership, and is the reason for its continual expansion.

### Friday, September 11.

PRESIDENTIAL ADDRESS by Dr. C. R. FAY on *Plantation economy* (10.0).

Miss MARGARET DIGBY.—*Russia and the Balkans : an agricultural comparison* (12.0).

The problem of all agricultural countries is the same—how to maintain or achieve a civilised standard of life for a rising population on an inelastic land area. The Balkans seek their solution in a voluntary intensification of farming, valuable crops grown on small independent holdings with co-operative marketing and finance and considerable state control of foreign trade. The Soviet Union has turned to large-scale mechanised cultivation of essential foodstuffs on collective farms, carried out by a membership of crofter-labourers, with production minutely planned and mechanised services supplied by the State but with home marketing still partly individual and unorganised. How do these two systems compare in their results and potentialities?

AFTERNOON.

Film : ' Tea Plantations ' (3.0).

### Monday, September 14.

Sir WILLIAM BEVERIDGE, K.C.B.—*An analysis of unemployment in Britain* (10.0).

The total of unemployed persons recorded each month by the Ministry of Labour does not consist of homogeneous units. In order to understand the nature of unemployment, the total must be broken up and analysed in various ways.

1. By industries. Even industries now prosperous and expanding show percentages of unemployment of 6 or more. ' Friction ' due to people being of the wrong type or the wrong place to meet the demand, and seasonal fluctuations, account for a very substantial volume of unemployment not likely to be abolished by increase in the demand for labour. On the other hand, other industries, depressed and contracting, have large bodies of unemployed labour for whom an increase of demand is unlikely—the ' industrial level core ' of unemployment.

2. By duration of unemployment in the individual case. About one quarter of those now receiving benefit or assistance have been unemployed continuously for twelve months at least—many for much longer. Substantially the whole addition to the total of unemployment now as compared with 1929 (before the depression) consists of long-period unemployment. Short-period unemployment is probably less than at any time since the war.

3. By relation to the systems of insurance and assistance. Nearly half those now recorded as unemployed in the insured industries get insurance

benefit, rather more than a third get unemployment assistance, and the rest get neither. Some of them are men otherwise qualified who have been disqualified for social reasons or disallowed under the Means Test, but they include also a proportion of people with little record or prospect of employment, a 'personal hard core.'

4. By ages. The risk of losing one's job does not increase appreciably with advancing years from 35 to 64 and is highest before 35, but the difficulty of finding fresh employment, once a job has been lost, whether through general depression or through individual misfortune, does increase materially with age. Social steps seem to be called for to help older men of proved industrial capacity to find new openings, and to counteract as anti-social the common tendency of employers to snatch at youth.

Mr. STEPHEN W. SMITH.—*Place and function of the administrative and technical worker in the new forms of economic organisation* (11.30).

The post-war developments in industry have been—as everyone knows—immense.

Changes in manufacturing method, developments in industrial organisation, improvements in technique, the steady replacement of steam by electricity as the power basis of industry, the increasing employment of the technician and the scientific worker—these and other phases of the new revolution in industry have modified tremendously the personnel of those employed.

Emergence to a new and increasing importance of

- (a) the technicians and scientific workers ;
- (b) the administrative staffs.

Simultaneous reduction, both in proportion and in significance, of

- (a) 'unskilled' labour ;
- (b) controlling and directing 'owners.'

Frequent replacement of latter, consequent upon group amalgamations or upon creation of large 'public utility' corporations, by salaried worksmen and similar responsible chiefs.

Simultaneous growth of municipal enterprise—as water, trams, electricity, baths, libraries, housing, aerodromes, etc.

What is the effect of all this manifest enlargement of the clerical, technical, supervisory, administrative, and professional grades ?

(a) Statistics reveal steady increase in ratio of such workers.

(b) Provided he is reasonably and adequately paid the salaried technician and administrator tends to be interested in the work for its own sake.

(c) Corresponding advance of the functional outlook as compared with the profit-seeking motive, of the interests of the public versus the privateering interest, of the sense of trusteeship versus the pull of proprietorship.

(d) Other considerations that emerge.

#### AFTERNOON.

#### SESSION on *Business administration* :

Mr. C. A. LEE.—*Some problems of a small manufacturing business* (2.30).

Of all the problems that are common to many small businesses, perhaps the more important are those concerned with the cultivation of a team-spirit among the staff.



This spirit will show itself in better co-operation, increased receptiveness to new methods and in added interest in work.

Good leadership is important and will bring with it a square deal for all concerned, adequate wages and good working conditions. The responsible staff must feel free to express ideas and have opportunity for advancement. The management must at all costs avoid a patronising attitude towards the workers.

Another difficult problem for the small manufacturer is that of keeping his methods efficient.

In place of the staff of experts employed by the large producers, the small manufacturer can use the services of consultants. The breadth of a consultant's experience and his freshness of outlook will make up for his lack of knowledge of the particular business, provided that the staff co-operate with him.

If consultants are selected wisely, and given adequate scope, a small organisation may soon reach the forefront of well-managed concerns, enjoying the advantages of vocational selection tests, motion and position study, rest pauses, centralised production planning and advanced technical methods.

Mr. E. S. BYNG.—*Administration as a profession* (3.30).

Administration is defined as the co-ordination and control of all the specialised activities concerned in industrial, commercial and other organisations. Owing to the growth in the size and complexity of industrial systems the responsibilities of administration call for the highest skill and the most careful training, to ensure that the true goal of industrial progress—the full co-operation of capital and labour—may be attained. The author claims that it is through the development and perfecting of a recognised profession of administration that the industrial and economic problems confronting the nation can best be solved. The necessity for early training in the fundamental principles of administration is emphasised, and courses of study leading from the elements to the higher techniques of administration are outlined.

## Tuesday, September 15.

Prof. P. SARGANT FLORENCE and Mr. A. J. WENSLEY.—*The localisation of industry* (10.0).

The concentration of particular industries in particular localities is at the root of the major problem of unemployment to-day, the problem of the depressed areas. This localisation is a matter of degree, and an accurate measure of the degree to which any industry is localised or to which any locality is devoted to any particular industry must be the first step in studying ways and means of restoring the depressed areas to economic prosperity. These measures, which are described in detail, make it possible to grade industries into those that are 'spread' over the population and not localisable, and those that are localised to various degrees. Moreover, with some knowledge of technical conditions and the reasons for the actual location of an industry, it is possible to divide the localised industries into those capable of transference into depressed areas and those where transference is not feasible.

Mr. S. R. DENNISON.—*The location of industry and the depressed areas* (11.0).

The problems of the depressed areas are partly the result of changes in industrial location due to various general changes in industrial structure.



Transport costs and supplies of specialised labour could explain a great deal of the nineteenth century pattern of location ; although still dominant in some cases, these are of much less importance in the new industries which can absorb the surplus workers from the old staples.

An analysis of the factors in the location of the growing industries: transport ; the demand for labour ; the market ; other elements, including 'arbitrary' and non-economic factors, and the various beliefs which may influence the industrialist in choosing a location.

This analysis, together with other considerations, suggest that the depressed areas will not be able to attract new industries with any greater success in the future than has been the case in the past.

Local and individual effort being limited, the control of location by the State is often suggested ; this has certain implications which are often overlooked, but which would be of great importance in an attempt to apply such a policy.

*N.B.*—The factors considered will be illustrated largely by reference to conditions in Lancashire.

Mr. W. PREST.—*The Lancashire coal industry* (12.0).

The problems confronting the Lancashire and Cheshire coal industry are complicated by the wide diversity of technical and commercial conditions in the coalfield. The industry as a whole, however, enjoys easy access to extensive local markets, and this makes possible a higher level of prices and costs than prevails in any other important coalfield. Nevertheless the Lancashire coal industry has to meet considerable and increasing competition from neighbouring districts. The industry has consequently declined until to-day output is only about half as great as before the war. This decline is unique among the Midland coalfields and is comparable only to that of exporting districts such as Durham and South Wales. The issues raised are of great social and industrial importance, and they also have some bearing on the theory of industrial location.

### Wednesday, September 16.

Dr. JOHN THOMAS.—*The Pottery Industry and the Industrial Revolution* (10.0).

The traditional view is that the Potteries either escaped or experienced a belated Industrial Revolution. This paper challenges this traditionally accepted view by producing documentary and other evidence of a steady and unbroken sequence in the economic transformation of the pottery industry, from about 1730 to 1850.

The progressive application of steam power to pottery productive processes is traced from documentary evidence, culled from the Boulton and Watt and other archives, hitherto neglected.

Intimate relationship between the mechanisation of pottery processes and the increase of output.

Potters as coalmasters, and the parallel application of steam power to the North Staffordshire Coalfield. Josiah Wedgwood as a steam power pioneer and patron of Boulton and Watt. The significance of steam power in converting the pottery workshop into a factory. New light on the pottery 'turn-out' of 1836. The transport and commercial revolutions, which accompanied the industrial changes. New light on the first attempt at a National General Chamber of Manufacturers. How the consumer

benefited from the Industrial Revolution in the Potteries. Part played by science and art in the production of ceramic wares. Economic interpretation of the localisation of the industry. The Industrial Revolution still proceeding in the Potteries.

Mr. C. J. M. CADZOW.—*Agricultural co-operation and organisation in Scotland* (11.20).

The history of the Agricultural Co-operative Movement in Scotland is outlined shortly by tracing the development of the Scottish Agricultural Organisation Society—the ‘spear-head’ of the movement—since its early days. After dealing with the Society’s policy and activities in pre-war days, the reasons for a post-war change in policy are summarised. The steady growth of the movement is illustrated in a sketch of the development of the principal societies trading in agricultural requisites.

It is shown that, although considerable interest in the marketing of dairy and poultry produce has always been evinced in outlying parts of the country, little attention was paid by producers to the standardisation of quality and grading of other products until after the Great War.

After briefly sketching the history of several co-operative marketing societies, an outline is given of the objects of a new form of Egg Marketing Agency recently submitted to producers for consideration and in which considerable interest is being shown.

An indication is given of the policy of the S.A.O.S. in regard to large-scale marketing organisation, with particular reference to schemes under the Agricultural Marketing Acts and their effect on the Agricultural Co-operative Movement in Scotland.

## SECTION G.—ENGINEERING.

Thursday, September 10.

PRESIDENTIAL ADDRESS by Prof. W. CRAMP on *The engineer and the nation* (10.0).

Dr. C. C. GARRARD.—*The economic incentive of the engineer* (11.0).

Mr. L. THOMPSON.—*Description of the machinery of the amusement park* (11.30).

Dr. L. G. A. SIMS.—*Progress towards a test specification for incremental magnetic qualities* (12.0).

Following the author’s paper read before Section G at Norwich, the Committee of Section G expressed the desire that the proposals advanced in the paper should be carried forward as effectively as could be made possible. These proposals aimed at establishing a test specification for the incremental magnetisation of sheet steels, very large quantities of which are used by the electrical industry. In accordance with the Committee’s wishes the research work which is in progress was directed more particularly towards establishing the foundations for an international specification: a stage has been reached here which enables certain limits to be fixed and

pending full publication of the results a brief account of this work is given. But, concurrently with this work, a detailed questionnaire was prepared and circulated throughout this country, Europe and America. It has been accorded gratifying support, and valuable opinions are now available from many British designers engaged both in communication and in heavy plant engineering. In addition, the views of the design departments of selected European firms are included. An organised German view-point is made available by the Physikalisch-Technische Reichsanstalt through the co-operation of Herr Ober. Reg. Rat Dr. W. Steinhaus, and important proposals of a far-reaching character are put forward in his report. Comments and suggestions are made by Thos. Spooner, Esq., Chairman of the American Society for Testing Materials, by R. L. Sandford, Esq., of the National Bureau of Standards, U.S.A., by M. Jouaust, of the Laboratoire Centrale de l'Electricité at Paris, and by other authorities.

#### REPORTS OF COMMITTEES (12.30).

##### AFTERNOON.

Visit to Pleasure Beach.

#### Friday, September 11.

Mr. W. A. STANIER.—*Railway locomotive development* (10.0).

Mr. ASHTON DAVIES.—*L.M.S. traffic problems* (11.0).

Mr. H. J. DEANE and Mr. E. LATHAM.—*Preservation of sea beaches* (12.0).

The movement of beach material is discussed generally in its relation to the run of the flood tides and the general effect, by way of restriction, of the development of coastal defence works on such travel. The question of the desirability of restricting or prohibiting the removal of beach material is also dealt with and instances are given of prohibitions contained in the bye-laws of certain Catchment Boards against such removal.

The paper is not a technical treatise on the design and execution of works of coastal protection but gives, in some detail, reviews of some instances of more than usual interest where difficult problems have had to be solved or where failures have occurred in existing defence works.

Reference is made to the causes and remedies adopted in certain cases and some comprehensive descriptions of the conditions met with or troubles overcome in such well-known instances as Blundellsands, Swanage Bay, Lowestoft, Overstrand (Norfolk), Littlestone-on-Sea (Kent), Sidmouth, Eastbourne, Shoreham and Lancing, Rye Bay (Kent) and Blue Anchor (Somerset).

The paper is illustrated by a plan of the coast at Blundellsands, one or two typical cases of designs of sea walls and groynes, reproductions of photographs of defence works referred to and by lantern slides.

Mr. H. BANKS.—*Blackpool coast defence works*.

Visit to Preston Grid.

#### Saturday, September 12.

Excursion to Manchester Corporation Waterworks, Haweswater.



### Monday, September 14.

Mr. H. F. SHANAHAN.—*Electricity for the consumer* (10.0).

Prof. E. W. MARCHANT.—*A note on the operation of a variable oscillator for speech frequencies, with an iron cored choke* (11.0).

A demonstration using a dynatron form of oscillator, in which the inductance in the tuned anode circuit was of the iron-cored type. The variation in frequency is effected by varying the grid bias on the oscillator valve. In this way a range of nearly 4·1 in frequency could be obtained. The wave shape of the oscillations as shown by cathode ray oscillograms approximates to a sine curve, at the higher frequencies. The oscillator was applied to a vibrating monochord and could be used to exhibit the modes of vibration of the monochord, when the frequency was varied continuously over a considerable range.

Mr. A. W. LADNER.—*Beam wireless. The beam array, developments in design and influence on long-distance communication* (11.20).

*Preliminary.*—Chief difficulties of short-wave communication are fading and echo, and, until array systems were used, short waves were of no value for commercial communication.

*Arrays.*—Practical beam arrays were first developed for Imperial wireless and were of the broadside type. These arrays consist of a long line of 'in-phase' radiators giving maximum directivity normal to the line. Vertical directivity being a function of height, high arrays were necessary for efficiency, and thus broadside arrays have a high prime cost.

*Gain of arrays.*—The gain of a broadside array is 10 per square wavelength, and if arrays are used at both ends of a system, the total gain is the product of the gains each end. Thus a system having 10 square wavelength arrays each end would give a gain of 10,000, and early arrays approached these figures.

*Developments.*—By phasing the currents along an array line it is possible to bias the directivity to a direction in line with the array. In this case directivity in all planes is a function of length, and hence efficient arrays of low height can be built. This effects great economy in cost, and most modern arrays are of the 'in line' type.

*The influence of the array on communication history.*—Before beam wireless, overseas communication was by submarine cable. Great Britain had achieved a virtual monopoly of overseas communication owing to our possessing so many islands and countries dotted over the world, which materially assisted the growth of a cable network. Long-wave wireless had failed to compete with cable communication, but the beam established an immediate high-speed long-distance service, much above the needs of the time. Immediate results were the Government-sponsored merger of Cables and Wireless in Great Britain. But beam wireless was available to all countries, and the growth of foreign competition is slowly breaking Great Britain's monopoly of overseas communication.

Dr. F. W. LANCHESTER.—*Magnetic and electric units* (12.0).

## AFTERNOON.

DISCUSSION on *Traffic safety*.

Mr. E. H. FRYER.—*The application of science to the solution of road users' dangers and difficulties* (2.30).

The paper deals with the reduction of road accidents under four headings : (a) the road ; (b) the vehicle ; (c) the user ; and (d) the controller.

(a) The author forecasts the characteristics of a road system capable of accommodating future traffic requirements, and visualises national 'through' routes with at least two carriageways, cycle tracks, footpaths and horse rides of a net width for the whole of these facilities of 260 ft., with adequate super-elevation at acute bends, uniform non-skid surfaces and no interruption at crossroads.

Suggestions for improving the design of private motor vehicles are contained under classification (b)—e.g. the elimination of draughts and the control of temperature inside the car, the maintenance of a low centre of gravity without detriment to visibility and headroom or any restriction on the carrying capacity.

(c) The author refers to the need for engendering among road users a spirit of consideration, good manners and goodwill.

(d) The fact is emphasised that the mere making of laws and regulations is unlikely to achieve any considerable reduction in accidents unless legislation is so simple and clear that its common sense commands the backing of public opinion.

## Tuesday, September 15.

Dr. W. S. STILES.—*Headlight glare and illumination in fog* (10.0).

The problem of eliminating dazzle from motor-car headlights is formulated on scientific lines and the main methods which have been proposed for the elimination or reduction of dazzle are examined and their merits discussed. Attention is drawn to the possibilities of the polarised light system.

Various suggestions for improving visibility in headlight beams during fog are discussed. It is pointed out that tests on the use of coloured light have failed to reveal any advantage, and that such progress as can be made will probably result from the study of various light distributions in the beam.

Mr. R. G. BATSON.—*The effect of the road surface and its maintenance on road safety* (11.0).

The paper deals with the requirements of road surfaces as regards rugosity (or roughness), cleanliness, conspicuity, continuity, and surface irregularities.

It emphasises the need for information as to the coefficient of friction on 'wet' road surfaces over a range of speeds, including values at much higher speeds than those hitherto employed, and shows that the 'slipperiness' of a road cannot be judged by a single test at a speed of, say, 30 m.p.h.

Stopping distances of vehicles are shown to depend upon the characteristics of the coefficient-speed curve for the road surface.

Road surfaces are only slippery when wet, thus it is considered that the lubricating action of the liquid on the road is of primary importance. Research on this aspect of the road problem has been started and some of the preliminary results obtained are described.

The importance of a light-coloured surface is stressed and the results of some experiments are given.

Continuity on the road is considered to be necessary—such as continuity in conspicuity and rugosity as well as continuity in super-elevation, traffic signs, etc. Equal rugosity across the road is necessary as well as continuity in rugosity along the road.

Finally, the paper deals briefly with the bearing of surface irregularities on the safety problem.

Mr. H. RICARDO, F.R.S.—*High speed Diesel engines* (12.0).

AFTERNOON.

Visit to Leyland Motors, Ltd.

### Wednesday, September 16.

Dr. MARGARET FISHENDEN.—*Some measurements of radiation from combustion gases* (10.0).

Dr. R. H. EVANS and Dr. R. H. WOOD.—*Transverse elasticity of building materials* (10.45).

The paper deals chiefly with the transverse elastic and plastic strains in building materials when tested in both tension and compression. Experiments have been made on columns of concrete, sandstone, slate, granite, marble, and ebonite, attention being devoted to the transverse and longitudinal strains and to the influence of that characteristic inherent in building materials known as creep. The illustrations in the paper refer to concrete.

The results obtained show quite definitely that lateral creep does occur in materials like concrete and sandstone at the same time as longitudinal creep. This is true in both tension and compression. At the higher stresses in compression, namely, above  $\frac{1}{4}$  to  $\frac{2}{3}$  of the crushing stress, the lateral creep amounts to several times the longitudinal creep. It is suggested that this phenomenal increase in the magnitude of the lateral creep may be due to the formation of longitudinal cracks in the column. The diagrams given show the existence of 'elastic-after-strain' and that transverse strains form hysteresis loops under cycles of loading.

Dr. A. L. RAWLINGS.—*Sound locators for directing searchlights* (11.30).

## SECTION H.—ANTHROPOLOGY.

### Thursday, September 10.

PRESIDENTIAL ADDRESS by Miss D. A. E. GARROD on *The Upper Palæolithic in the light of recent discovery* (10.0).

Mr. A. LESLIE ARMSTRONG.—*The antiquity of man in Africa as demonstrated at the Victoria Falls* (11.0).

The Rhodesian Archæological Expedition, 1929, provided the opportunity to investigate the sequence of Stone Age cultures represented by implements known to occur in the gravels of the old river bed and terraces



of the Zambesi, south of Victoria Falls, and to obtain the co-operation in this work of the Rev. Neville Jones, of Bulawayo. As a result of systematic research covering an area on the east bank of the river, between the present line of the Falls and the fifth gorge, the sequence of cultures has been defined and their relation to stages in the recession of the Falls from their former position in gorge five to that which they now occupy has been determined. The material collected was first divided into cultural groups on the basis of type and afterwards each group was analysed on the basis of physical condition. The cultures represented are : (1) a Pre-Chellian industry which resembles in some respects the Eolithic and in others the Cromerian of Europe ; (2) Chellian ; (3) Acheulian, of which three sub-divisions are recognisable ; (4) Clactonian (2 phases) ; (5) Levalloisian ; (6) Mousterian ; (7) Bambata, which is the Rhodesian equivalent of the European Upper Aurignacian.

The degree of rolling to which the various groups had been subjected and the entire absence of rolling exhibited by tools collected on the plateau of the old river bed in certain areas, made it possible to relate each group to successive stages in the excavation of the river gorge, which is over 400 ft. in height above the present river and it is clear that a length of 5 miles of this gorge has been eroded since Pre-Chellian times.

Dr. T. A. RICKARD (read by Prof. J. L. MYRES).—*The nomenclature of archaeology* (II.40).

Current nomenclature is not in accord with anthropological facts. The idea that the polishing of stone was characteristic of the Neolithic period is condemned on the ground that the technique of stone fabrication is dependent upon the kind of stone available. It has no relation to chronology. Excessive emphasis on flint-knapping ignores the fact that flint is not available in many parts of the world.

The Neolithic as a period of time has shrunk to a negligible length. The gap between the end of the Palæolithic and the beginning of metal-smelting leaves less than a thousand years.

The Bronze Age is a misnomer. The use of the tin-copper alloy represents a minor phase of the use of copper, and characterised only a small part of the world. 'Early Bronze,' based on a faulty knowledge of metal culture, is due mainly to the failure to recognise the use of native copper long before smelting began.

The use of native copper does not mark a distinct Metal age ; it belongs to the Stone Age, and to the beginning of it. There was no Chalcolithic period, nor any twilight zone of metal usage between the Stone Age and the so-called Bronze Age. After the Stone Age came the Metallurgic Age. The extraction of metal from the ore by smelting is entirely distinct from the hammering of metal by stone and even from the melting of it for the purpose of making ornaments, as in Mexico.

The use of stone was preceded by the use of less recalcitrant materials, such as wood, bone, and shell. This covered a period of time longer than the Stone Age and distinct from it ; the name 'Primordial' is suggested. Therefore the three divisions suggested are Primordial, Stone Age, and Metallurgic.

Exception is taken to the term *Homo sapiens*. The connotation of wisdom is rendered ridiculous by human behaviour, even to-day. The one faculty that separates man from the beasts of the field is speech. Therefore *Homo loquens* is suggested.

Mr. W. J. VARLEY.—*The Bleasdale circle* (12.20).

The essential features of the Bleasdale Circle are: (a) An inner structure, comprising a central shallow grave, surrounded by eleven oak posts let into the ground, forming a ring 33 ft. in diameter. Around this post ring is a penannular ditch floored with birch poles laid crosswise. The upcast from this ditch formed a low mound 54 ft. in diameter through which the post ring protruded. The opening in the ditch was flanked by two rows of three posts, the innermost pair being much larger and deeper sunk than the others. (b) An outer palisade set eccentrically to the inner structure which it nearly touches on the east side near to the break in the ditch. This palisade is made up of principals—deep set oak posts at 14-ft. intervals between which are shallow set minor posts.

The monument is dated by its grave goods, a biconical pygmy cup and two cinerary urns. The latter belong to a late form of the overhanging ring type characteristic of the Pennines and to be attributed to a late phase of the Middle Bronze Age. After the circle had been built it was invaded by peat moss which on analysis proved to belong to the sub-Atlantic phase.

Taken as a whole Bleasdale is without known parallel. The inner circle bears obvious affinities to the Dutch palisade grave, particularly to Lange-dijk, but the eccentric palisade and the splayed approach or forecourt appear to be derived from other sources.

It is fairest in the present state of knowledge to regard Bleasdale as the result of the fusion of ideas surviving in isolation.

#### AFTERNOON.

Prof. R. RUGGLES GATES, F.R.S.—*Blood groups* (2.15).

The blood groups are generally regarded as human characters which are of mutational origin and non-selective. Their spread in different races must therefore depend upon mutation frequency, migration and racial crossing, unless they are linked to racial characters having selective value. The A and B blood groups occur also in anthropoids, but it appears probable that they have arisen independently as parallel mutations in man. This is partly based on the fact that the chimpanzee and gorilla, which are regarded as man's nearest relatives, have hitherto shown only the A and not the B blood group. O appears to be the primitive condition, from which A and afterwards B began to appear as mutations. That A is older is shown by its high frequency in Australian aborigines, pre-Dravidians of India, Bushmen, Lapps and Hawaiians. B began to appear later in East and South Asia and in Africa. The fact that American Indians and Eskimos of pure blood are nearly all O has been difficult to explain, but peoples of similar physique, such as the Tso of Formosa and the Tungus, have a high percentage of O and may represent an ancestral type. The few Tibetans tested are, on the other hand, very high in B.

Mr. E. DAVIES.—*An anthropological survey of the Isle of Man* (2.55).

Anthropometric data were recorded from each of 1,200 adult males of Manx descent. Preponderance of fair colouring on the Northern plain and in South, and of dark colouring in the east-central region, is most marked among long-headed men.

In the north stature is taller and build is more massive than elsewhere, especially among fair men. The north also shows longer faces and narrower noses than other parts. Thus the north is characterised by tall, fair, big-boned, long-faced, narrow-nosed, and, on the whole rather long-headed



men ; a marked occurrence of Norse place-names and archæological finds indicate Norse settlement here. In the east-central area we find a preponderance of dark colouring, shorter stature, smaller measurements, and shorter noses. Other regions of the island show differences of varying degree. The island shows no obvious survivals of early extremely long-headed types and the distribution of dark-haired, very broad-headed men is but a lightly scattered one.

The bulk of the population is either fair and rather long-headed or medium headed, with a tendency to tall stature, or darker, with smaller measurements, but on the whole very similar cephalic indices.

Mr. H. FULLARD.—*Anthropometric work in Lancashire* (3.35).

The work so far accomplished ; the earlier efforts ; the present survey. The number of subjects measured ; the localities in which the measurements have been taken ; the plain and the hills. The results and indications of the work ; the distributional value of the more important measurements, indices, and degree of pigmentation. The groups of associated characteristics and their distribution ; the relation of the latter to the relevant aspects of the geography and life of Lancashire. Conclusion : the intention of further work.

### Friday, September 11.

Mr. E. DAVIES.—*Rural settlement in the Isle of Man* (10.0).

Land in the Isle of Man is divided into treens and quarterlands. The treen usually, but not always, comprises four quarterlands. The boundaries of these, which are traditional and fixed, tend to follow natural features—hedges, roads, streams, etc. In lowland areas they often follow lines of wells ; in the upland, watercourses are more commonly the bounds.

In valleys, treens occupy hill slopes between streams rather than valley bottoms. On the coastal plateau, away from valleys, and on the moraine in the north the treens extend from hill to shore in long parallel strips. This provided an equitable division of land of various kinds.

The closest affinities are with the land system of ancient Ireland. The Manx treen (or 'Balley,' which was the original term) and quarterland (Manx 'Kerree-Valley') resemble the Irish ballys and quarter-ballys. In Ireland thirty ballys formed, ideally, the land of a Tuath ; in Man each sheading includes, approximately, thirty treens.

Many features of the legal tenure, according to Manx customary law, have been shown to resemble those governing Odal land in Norway. They appear to be Norse features laid over an older land system.

Mr. I. C. PEATE.—*The moorland Long-house in Wales* (10.35).

The influence of environment upon human habitations is well exemplified in Wales. It is illustrated by the characteristic thatched cottages of the Glamorgan coastal plain and the intrusion into mid-Wales of the half-timbered house of the Severn Valley and the Midlands. But of particular interest to the geographer and anthropologist is the long-house of the Welsh moorland in which man and beast are (for reasons which will be discussed) housed under the same roof. The type is of extreme antiquity and early Welsh references to it will be given. Attention is drawn to associated types in Scotland and—in ancient times—in Scandinavia and reference made to features in North Wales cottages which appear to be related to the type.



Dr. E. WILSON.—*The folk-tale in Westmorland and North Lancashire* (II.10).

The area : South Westmorland and Cartmel. Influence of system of tenure on social life. Small-holders and hard-workers. Changes last century—enclosures and growth of estates. More recent changes, decline of industries and local life.

Traditional amusements : dances, songs, tales. Hunting songs still sung. References in local books, singing competitions at Winster and Eskdale. Former popularity of chap-books (*cf.* Wordsworth and Briggs). Competitions in telling riddles. Parties where each guest must sing a song or tell a tale. Tales still told, though they are now dying out. Influence of the dialect in preserving tales.

Humorous tales. The daft man in the daft village. The man who makes an object that is too big to be got out of his workshop. Gotham. Hazel Grove near Stockport ; folk use of modern conditions, and tales circulated by troops in the Great War. The inhabitants of Barrowdale (Cumberland)—early version of Cuckoo story in Briggs. Modern version. Degeneration in story.

Effect of chap-books. Modern parallel of dialect pamphlets. Story of the three foreigners in chap-book and from the folk. Modern version again deteriorated.

Story of Farmer and his wife—Poggio. No degeneration.

King John and the Abbot. Old tale but modern conditions. Tales likely to die out because of modern conditions. Necessity of collecting now.

Mr. S. Ó.DUILEARGA.—*The work of the Irish Folklore Commission* (II.45).

In April 1935, the Irish Folklore Commission was set up by the Irish Free State Government to collect oral traditions of the Irish people still remaining in both Irish and English. The Commission inherited from the Irish Folklore Institute 50,000 pages of manuscript material, and the nucleus of a Folklore Reference Library.

Through the courtesy of University College, Dublin, the Commission's headquarters is in the University building.

A great reservoir of tradition is in the Gaeltacht. Here are storytellers with unbroken tradition from the Middle Ages possessed of amazing repertoires of tales and songs, and imbued with an outlook completely untouched by the Machine Age. To save and preserve these traditions, six full-time collectors have been appointed and equipped with recording apparatus, and four more will shortly be appointed. Records and notebooks are sent to headquarters to be catalogued and preserved.

The Commission also has correspondents all over the country collecting materials in leisure hours. Notebooks have been issued by the Director of Education to 6,000 Primary Teachers throughout the Free State. These are catalogued and stored, and will provide a general survey of the whole country.

All material which will throw light on the social life of the Irish people in the past is also being collected. In 1935 Dr. Campbell (Upsala) and Mr. Nilsson (Lund) made a survey of house types, modes of agriculture, fishing, etc. Hundreds of plots, plans, and sketches were made, and have been stored.

The headquarters of the Commission and the Reference Library are open to students and scholars.

Mr. J. HORNELL.—*The coracles and curraghs of the British Isles* (12.20).

Coracles are small river craft, propelled by paddles ; in shape, round, ovate or sub-rectangular. Curraghs are sea-going boats generally built on the lines of a light skiff and propelled by oars. Both were originally of wicker-work covered with hide, but tarred canvas is now the usual covering upon a frame of crossed laths.

In Europe they occur to-day only in the British Isles. Lucan mentions the use of coracles on the river Po at the beginning of the Christian era ; classical writers occasionally make passing references and thereby suggest a wider distribution in those days.

In Wales coracles exist on the rivers in the south-west and on the Dee in the north. In England a bowl-shaped form serves as a ferry-boat on the Severn. In Scotland they were in use from the Hebrides across to the Spey in the second half of the eighteenth century, and in Ireland they linger on the Boyne. To-day, curraghs are restricted to the west coast of Ireland ; the design differs from port to port and in size varies from 8 to 20 ft. in length.

Prior to the establishment of Roman rule the presence of curraghs throughout Britain is attested by Greek and Roman writers.

Coracles and curraghs are definite features of Celtic culture in Britain. The former were probably introduced from the continent by early Celtic swarms whereas the curragh is a local adaptation of wattle and hide technique to boat construction. A weighty reason for the initial adoption, and for the persistence to the present day, of the curragh type of vessel must have been that the Celts found in its design one suitable to the rapid and inexpensive construction of a light type of boat, adaptable to many of the purposes for which their Scandinavian neighbours employed plank-built boats superior in many respects to their own dugout canoes. Once the system was adopted, its usefulness would quickly bring about improvement in technique and dimensions, with the increase either of commerce or of raiding. Curraghs are capable of extremely rapid manœuvring and of higher speed under oars than wooden rowing boats of like size ; hence their employment by coastal pirates as instanced by Sidonius and Gildas. But the vulnerability of the hide cover forbade its use in sea-fights with stouter vessels built of wood. Because of this the clinker-built long ships of the Saxons drove the piratical Celtic curraghs out of the English Channel, and roomy round ships took their place as trading vessels. Only on the wild west coast of Ireland are curraghs still in use because of poverty, reinforced by faith in their good qualities when handled skilfully.

#### AFTERNOON.

JOINT DISCUSSION with Section D (Zoology) (*q.v.*) on *Genetics and the race concept* (Section D room) (2.15).

### Saturday, September 12.

Excursion to Bleasdale, Ribchester, Preston.

### Sunday, September 13.

Excursion to Furness Abbey, Urswick and Cartmel.



### Monday, September 14.

Prof. C. DARYLL FORDE.—*Social change in a West African village community* (10.0).

Despite the dominance of patrilineal territorial kin groups in the organisation of economic activities in the Yakö villages, authority and legal decisions within the villages have lain with a number of priest-chiefs whose prestige and authority derive not from those kin groups but from co-existing matrilineal groups.

This situation is, however, being seriously challenged. The establishment under government authority of a native court, and the creation in connection with it of warrant chiefs, proposed by aggregations of patrilineal kin groups, together with the suppression or decay of the punitive action of societies, have restricted the authority and the powers of the priests' council, while the establishment of external authority has reduced its prestige.

In connection with the proposal of the Government to create a native authority intended to reflect and implement native law and custom, there is a strong demand by a group of younger men that the council of the priests of the matrilineal kin groups shall be entirely ignored. This vocal group desires a council composed of spokesmen of patrilineal kin groups alone. Motives behind this are many and confused. Loyalty, within the matrilineal groups is, however, very strong among the majority, and their rituals have great prestige, so that a serious internal conflict has developed which involves the fundamental social organisation of the community.

Dr. D. JENNESS.—*The backwardness of the American Indians and its causes* (10.35).

Why were the Indians backward?—'Pure' races—Intelligence of races and peoples—Temperaments of peoples—Influence of 'race-mixture'—Wave-like progress of civilization—Influence of climate on civilization—Culture contacts and their effects on civilization—Backwardness of Indians partly due to isolation—Later dawn of civilization in America—Similarities and differences in the growth and spread of New and Old World civilizations—Influence of physiographic conditions in the Old and New Worlds—Rise and decline of nations in America—Conclusion.

Dr E. J. LINDGREN.—*Russo-Tungus culture contact* (11.10).

The Reindeer Tungus of north-western Manchuria and the Russian Cossacks with whom they have been trading for at least seventy years provide an example of contact between an aboriginal and a European culture which has several unusual features. Despite their long association, there is no perceptible tendency for one culture to eliminate, or to fuse with, the other; cordial social relationships coexist with freedom in internal administration, and differences in race and culture appear to cause no hostility.

Among the factors which probably contribute to this state of cultural equilibrium are the approximate numerical equality of the two communities and their partial economic interdependence. The circumstance that cultural borrowing has taken place in both directions is perhaps of still greater importance. Thus Tungus summer dress is largely Russian in material and style, while Cossacks hunting in the woods in winter wear leather garments either of Tungus manufacture or tanned by a Tungus method. In the sphere of religion there is a similar interchange: the Tungus follow most



of the outward forms of Russian Orthodox Christianity, but the Cossack traders share their belief in the Tungus shaman's powers.

Miss E. D. EARTHY.—*The social structure of a Gbande town (Liberia)* (11.45).

A typical village of the Gbande tribe of Liberia is described. The Gbande are allied to the Kpelle.

A hunter, N., makes his home on a hill-top, and during five generations a village of fifty huts has grown up. The village is divided into three sections, each section, called *wubi*, being governed by its headman under the chief, who in his turn is subordinate to the clan chief. The community shows a patrilineal—patrilocal society emerging from a matrilineal—matrilocal one. Reasons given. The chief totem is the python. The tribal religion has been invaded by a degenerate Mohammedanism. Latterly there have been one or two converts to Christianity.

The chief occupations are hunting, fishing, cotton and rice cultivation, palm-oil production, cloth-weaving, basketry, mat making, iron smithery. Iron currency is used for bride-wealth, but this is not paid when the man comes to live at his wife's home.

A ground-plan shows the relative positions of the huts and their occupants, together with the sacred enclosure for the 'Lightning-medicine'; the burial mound of the founder of the village, and the graves of important women built as excrescences on the walls of their huts.

Sir RICHARD PAGET, Bt. (read by Dr. G. M. MORANT).—*Sign language in relation to human speech* (12.20).

Auditory language is a system of mouth gestures expressing meaning. Its derivation from bodily pantomime is explained by the natural sympathy between hand- and mouth-movements observed by Darwin.

The natural, universal, pantomimic language of man is still used by uneducated deaf mutes throughout the world. It does not employ gestures corresponding to words—it pantomimes events as a whole.

Man is not primarily a tool-using animal; he is rather a symbol-using animal.

Speech was born when separate signs were evolved for separate ideas. The corresponding mouth gestures were combined with the emotional language of grunts, chuckles and cries, and ultimately produced speech.

Sign language could be logically developed so as to express the highest and subtlest thoughts of man.

Auditory speech superseded sign language because it required less effort—left man's hands free—and did not need light or direct vision for its understanding.

The development of speech is retarded by pedantry, from which sign language is at present free.

A rational sign language would appear natural to all races, and be very easy to learn and remember; its development could be controlled from the start by a world authority through the medium of films and television.

#### AFTERNOON.

Mr. E. G. BOWEN.—*The travels of the Celtic saints in the Dark Ages* (2.15).

The development of prehistoric studies has made possible the reconstruction of a fairly complete sequence of cultures during the last two millennia B.C.

on the western fringes of Europe. It is important that the semi-legendary material of the proto-historic period should be re-examined in the light of the prehistoric evidence. This paper seeks to show, by plotting as far as possible the journeys of prominent Celtic saints, that the conditions of travel and the routes frequented in the Dark Ages were much the same as the carhæological evidence leads us to believe had been the case in these western lands for nearly two thousand years before. By plotting the various churches, wells, shrines, etc., dedicated to respective saints, it is possible to indicate geographically their spheres of influence. An examination of these shows that many areas on the western fringe of Europe which, apparently, functioned as cultural sub-provinces in prehistoric times, stand out again in the Dark Ages as the territorial limits of the missionary influence of a particular saint. Very seldom does the sphere of influence of an individual saint extend over the whole of the Celtic lands.

Mlle. SIMONE CORBIAU.—*Recent finds in the Indus valley* (3.0).

The object of this paper is to lay before the British Association documents coming from a new archæological area in the Indus valley.

This region is the Peshawar district, in the uppermost corner of the North-West Frontier Province of India. It was hitherto supposed to contain only remains of Greco-Buddhist times. Yet a journey of investigation and trial diggings have enabled me to bring back to the Brussels Museum a collection of archaic pieces which I deem to be far more ancient. In my opinion they represent a very early stage of the Indus valley civilisation. All the parallels they afford are to be found in Sumerian Mesopotamia (Jemdet-Nasr period and Susa II), protohistoric Aegean (Ancient Minoan I) and at the prehistoric site of Anau in Russian Turkestan. Excavations in this archæological region might throw much light upon the origin of the Indus culture.

Dr. M. A. MURRAY.—*Anthropology as applied to English history* (3.30).

The methods of Anthropology, when applied to the study of English history, disclose some strange facts, and suggest that in the lives of the monarchs of Western Europe there is a hitherto untouched field of research. The evidence shows the survival as late as the eighteenth century of the belief in the actual divinity of the king, and with that belief there goes also the belief in the necessity of the divine victim, who was either the king or a substitute. The perpetual recurrence of the number nine and its multiples, either as the age of the king or as the number of years of his reign, when taken in connection with the sacrifice of a victim, cannot be mere coincidence. The evidence, if found in modern Africa or in ancient Greece, would be received without more ado as proof positive of the existence of this custom. Therefore the custom must be accepted as occurring in England. In ancient pagan times the sacrificed victim was deified, prayers and offerings being made at his tomb; in Christian times he was canonised, and like his pagan prototype, he received worship after death. Examples of such sacrifices can be found in English history from the time of the Saxon kings till the end of the Stuart period.

Prof. H. J. FLEURE, F.R.S.—*The science of man and the problems of to-day* (5.0).



## Tuesday, September 15.

Dr. J. POKORNY.—*The racial and linguistic affinities of the neolithic Danubians* (10.0).

The question of the origin of the Danubians is of the greatest importance, owing to the fact that they introduced domestic animals and cultivated plants into Central Europe. Their anthropological remains are, however, scanty, and owing to their mixing with their mesolithic predecessors, admit of various interpretations. It is certain that the Mediterranean race is an important element among them. Though completely submerged by the conquering Aryans, they must have transmitted to them the names of rivers and villages, being sedentary peasants.

In the home of the urnfield culture in Czechoslovakia and eastern Germany, which the author has shown to be Illyrian, we find many names that cannot be explained from Aryan roots. Since this culture consists chiefly of Danubian elements overlain by the Aryans, we may expect the non-Aryan names to be of Danubian origin. It is certainly more than a strange coincidence that these very names can be shown to be distinctly Etruscan. Since we know that the Etruscans had absorbed the native Mediterranean population of Italy in a very large degree, these analogies may be due to the common Mediterranean element and give us a definite clue to the origin of the Danubians.

Mr. E. E. EVANS and Mr. O. DAVIES.—*Stone circles in Northern Ireland* (10.30).

Considerable quantities of stone circles, usually in groups of four or five, are found in co. Derry and Tyrone, and some in Donegal, which has, however been little explored. They are not known in the eastern and southern counties of Ulster, so they seem to have been introduced by the Foyle estuary, probably from the north. They are usually about 25 ft. across, of flat slabs on edge about 6 in. high. Sometimes they contain a small grave structure, and three or four types can be distinguished by the presence of alignments, etc. From the evidence of distribution and of the typology of the graves contained in one of them they should be assigned to the late Neolithic period.

Miss LILY F. CHITTY.—*The Irish Sea in relation to Bronze Age culture* (11.10).

The evidence is presented in a series of maps of type objects of the Bronze Age showing their distribution around the shores of the Irish Sea and extending the survey east to the Pennine passes and south to the mountains of North Wales, the Isle of Man forming a focal area for the overlap of types.

A basic stone-celt culture was metamorphosed by the idea of the perforated stone axe-hammer from Yorkshire, but this scarcely affected Ireland. Diverse elements were linked by trade across Britain in flat bronze axes from Ireland and by traffic in precious substances. Interesting ceramic hybridisation resulted. The Eden, Ribble, and Mersey basins afforded early communication routes. Distinctive forms of Middle Bronze Age implements developed in the Upland Zone of Britain. Short-flanged Yorkshire axes have an instructive distribution.

Late Bronze Age upheavals sent Scottish makers of large cinerary urns



among Ulster food-vessel potters, and resultant ceramics reflexed to the opposite shores of the Irish Sea and Wales. Bronze-equipped swordsmen traversed Ireland and local variants of their panoply evolved. Thereafter much of the Irish seaboard, isolated from the Early Iron Age developments in Lowland Britain, declined into an ' Ultimate Bronze Age ' (Grahame Clark) that may have persisted till Roman times.

Miss M. DUNLOP.—*The significance of the limestone escarpments in the life of Bronze Age France* (12.0).

The first instances of the significance of the limestone and particularly of the oolitic escarpments are very much earlier than Bronze Age times, but the extent to which the organisation of society and economy had developed at this stage justifies the choice of this period to demonstrate that significance.

The paper, with the aid of distribution maps (chiefly of objects of material culture), aims to establish the position of various groupings on the mainly forest-free escarpments, and to discuss their relations with the non-calcareous hinterland. Further diagrams illustrate the importance of individual limestone ridges and the use of the belt as a whole, in their effect on internal trade and migrations and invasions of peoples.

Illustrations are given, with the aid of tentative reconstructions of the former vegetation of France, showing the direct connection between changes of climate and the utilisation of the limestones.

Specific examples are given to elucidate regional detail, and the possibilities for the growth of unique autochthonous groupings along the limestone scarps of Central France, are contrasted with contact metamorphism along the peripheral regions.

AFTERNOON.

Dr. D. JENNESS.—Film : American Indians (2.30).

## SECTION I.—PHYSIOLOGY.

Thursday, September 10.

Dr. H. E. COLLIER.—*Practical recognition of fatigue in industry, being a discussion of the clinical aspects of the subject* (11.0).

The study of Industrial Fatigue is in a state of confusion. It has been approached hitherto from three independent angles by the Physiologist, the Psychologist, and the Industrial Engineer. The isolated studies of specialists have not been brought together or properly related to each other. The physiological manifestations of fatigue, the psychological feelings of fatigue and the economic results of fatigue are all aspects of a deeper unity. That unity should be studied by the Industrial Clinician, who, aided by the specialists concerned, should be able to recognise the existence of the Fatigue-Syndrome, to differentiate Industrial from Non-Industrial Fatigue, and to indicate the probable sources of fatigue wherever it occurs. The cure and prevention of fatigue in industry will be achieved by the combined efforts of the practical experts concerned.

In this paper an attempt is made to set out a scheme for the practical diagnosis (personal and collective) of 'Fatigue in Modern Industry.' Certain special causes of fatigue which are commonly overlooked are briefly discussed, and the method of diagnosis explained.

Dr. H. M. VERNON.—*Fatigue in industry* (11.30).

The physical fatigue experienced by industrial workers depends (a) on the length of time for which they have to work, (b) the character of the work, and (c) the conditions under which it is performed. (a) Hours of work were greatly improved after the war, when the working week was cut down from 52–55½ hrs. to 47–48 hrs. in most occupations; but some groups of workers still suffer from over-fatigue caused by excessive hours of work. The majority of coal miners still work 8-hour shifts; again, many bakers work from 70–80 hours a week, while shop assistants and employees in the distributive trades frequently work unduly long hours. (b) If the work is of a heavy character, the fatigue induced can often be lightened by the introduction of rest pauses at regular intervals. Also the adoption of the most suitable movements, of an easy and rhythmic character, may reduce fatigue; but time and motion study resulting in undue speeding up must be avoided. (c) Suitable environmental conditions are very important. Good lighting may increase the quantity and quality of the work produced substantially. Heating, if insufficient, induces cold fingers and diminished manual dexterity; if in excess, and especially if accompanied by inadequate ventilation, it causes extra fatigue and diminished production. Noise, if excessive, has adverse effects, both subjective and objective.

In addition to its direct effects, reduction of fatigue acts indirectly by diminishing liability to accidents. While good progress has been made of recent years in adopting measures for reducing fatigue, much remains to be done. The principle of the 40-hour week, with maintenance of the workers' standard of living, was adopted by the International Labour Conference at Geneva last year.

Dr. G. H. MILES.—*Fatigue from the industrial point of view* (12.0).

GENERAL DISCUSSION (12.30).

AFTERNOON.

Excursion to Open-air Swimming Pool, Blackpool South Shore.

### Friday, September 11.

PRESIDENTIAL ADDRESS by Prof. R. J. S. McDOWALL on *The control of the circulation of the blood* (10.0).

DISCUSSION, with representatives of Sections A (Mathematics and Physics) and B (Chemistry), on *The architecture of life* (11.0).

Dr. A. D. RITCHIE.—*Introduction*.

Dr. D. M. WRINCH.—*Molecular structure of living matter*.

Great advances have recently been made in investigating the structure of hair, silk and other products of living organisms. The crystalline character

of these products suggests that the substances more intimately concerned with the processes of living organisms—above all the chromosomes themselves—may also be crystalline. A molecular model for the chromosome is suggested consisting of molecules of protamine-nucleate (cp. *Nature*, vol. 134, p. 978 (1934); vol. 135, p. 799 (1935); *Protoplasma*, vol. 25, p. 550 (1936)). Molecular models of the protein molecule are also put forward for consideration (cp. *Nature*, vol. 137, p. 411 (1936); vol. 138, p. 241 (1936)).

Mr. J. S. MITCHELL.—*The chemical mechanism of the action of ultra-violet radiation on proteins.*

Mr. O. GATTY.—*The electrical potential differences across the frog skin—some observations on the relationship with oxygen uptake.*

Dr. P. EGGLETON.—*The diffusion of solutes through muscles.*

Dr. J. H. QUASTEL.—*Enzymic activity of the cell and cell structure.*

GENERAL DISCUSSION.

#### AFTERNOON.

Dr. H. M. VERNON.—*The relation of alcohol to road accidents (2.0).*

Everyone admits that the liability of motor vehicle drivers to road accidents is increased by the consumption of excessive quantities of alcohol, but in spite of the large mass of evidence to the contrary obtained by laboratory tests, some drivers maintain that moderate quantities have no effect, or improve their driving. Direct tests on the roads are very difficult to make, and as an alternative the motor driving apparatus designed by Miles and Vincent, and installed at the National Institute of Industrial Psychology, was used. The subject drives a dummy car along a track projected as a moving picture on the screen in front of him, and the path taken by the car is automatically recorded. The subjects performed tests 1 hr.,  $\frac{1}{2}$  hr. and 0 hr. before taking the experimental dose, and  $\frac{1}{2}$  hr., 1 hr. and  $2\frac{1}{4}$  hrs. after it. The dose—which was taken on an empty stomach, three hours after the last meal—consisted of whisky containing—as a rule—30 c.c. of alcohol (i.e. rather more than a 'large' whisky), or of mild beer containing only 5 c.c. of alcohol. On the fifteen experienced drivers examined the mild beer had no effect, but the whisky, in contrast, caused a reduction of 6 per cent. in the driving time, and an increase of 12 per cent. in the driving errors. In the five non-drivers tested, however, the mild beer had more effect in reducing time and increasing errors than the whisky. The various subjects differed greatly in their reactions, but half of them had their driving time reduced by 10 to 24 per cent. As a rule the drivers were quite unconscious of any speeding up after drinking alcohol, and this suggests that (a) even moderate quantities of alcohol should be avoided before driving, and (b) all cars ought to be fitted compulsorily with speedometers.

Alderman W. MELLAND.—*Playing fields and their relation to character and health (2.30).*

The paper deals primarily with the birth of the Playing Fields movement in this country. It was discovered ten years ago that there was a sad dearth of playing fields owing to no one realising in the past the great need for these fields. Our forefathers showed no vision in this respect.



A return is given stating what has been done so far by the National Playing Fields Association. It is noticeable that playing fields figure largely in recent national appeals.

Like many other good causes it has been private initiative that has brought the subject of playing fields to the front. Town-planning authorities are now well awake to the situation and they are urged in this paper not to lose sight of the fact that recent clearance schemes should be carefully zoned with a view to open spaces for games. Apart from facilities for games, small and numerous playgrounds should be provided for children so as to safeguard them from the dangers of the streets.

It is important to stress the great benefits accruing to the building up of character in all its aspects from the playing of well ordered and disciplined games; this is of importance probably equal to, if not greater than, the development of physique.

Local authorities through their education and parks committees are becoming more and more aware of the necessity for playing fields owing largely to pressure put on them by playing fields societies. The Board of Education is putting pressure on local authorities to provide for playing fields attached to the elementary schools.

An association called the Central Council of Recreative and Physical Training has recently been formed which embodies practically all the activities in the kingdom which work for physical development, such as the Keep Fit Movement, etc. This body has entered into an arrangement with the National Playing Fields Association for joint working, and should make for greater efficiency in working, as the two bodies are complementary to each other.

Mr. A. F. DUFTON.—*Food for thought* (3.0).

Although there is a general impression that the optimum diet is probably not much in excess of the minimum, the minimum diet necessary to support human life is still unknown. Attention is invited to Rumford's experiments on nutrition and it is suggested that Hindhede may perhaps be right in his contention that the science of nutrition as it finds favour to-day is based on over-feeding. Experiments are described with a diet containing 32 grams of protein and providing 1300 calories and with a diet containing 30 grams of protein and providing 960 calories. The basal metabolic rate fell to the unprecedented value of 338 calories per day. The loss of heat from the human body is discussed.

Mr. C. S. HALLPIKE, Prof. H. HARTRIDGE, F.R.S., and Mr. A. F. RAWDON SMITH.—*The phase charge effect on the cat's ear* (3.30).

If a beam of light is passed through the slots of a rotating screw disc and is caused to fall on a photo-electric cell, voltages are set up which fluctuate at a frequency which depends on the rate of rotation of the disc. If these voltages after amplification are fed into a loud-speaker a musical tone is produced. With suitably shaped slots this tone may be freed from over-tones, and with a further change in the slots a change of phase of  $\pi$  in this tone may be produced one or more times with each rotation of the disc. When this phase-changing tone is fed into a cat's ear the Wever-Bray effect records the phase change faithfully as a good telephone would do. The response in the auditory tract differs, and consists of a rapid decrease of the amplitude of the nerve responses to zero followed immediately by a rapid increase of their amplitude to the original value. The auditory tract

response is in keeping with the beat which is heard by an observer each time the phase is changed.

### Monday, September 14.

Dr. O. KESTNER.—*Stimulating climate, sheltering climate, personal climate* (11.0).

Strong and healthy adults are influenced by climate only to a very slight extent. One can study the influence of climates only on children, patients, or weak and sensitive persons.

From this standpoint, not from the standpoint of meteorologists, we can divide the climates of Europe into two types, the sheltering climates and the stimulating climates. The sheltering climates are found in forests, lower hills, and seaside resorts protected by cliffs and heated by the Gulf Stream drift. The stimulating climates are found in the high altitudes and in seaside resorts exposed to winds and to direct sunshine.

Sheltering climate is good for weak and sick people, but it does not help for growth and development.

In the stimulating climate are observed :

- Growth and development.
- Increase of hæmoglobin.
- Increased combustions.
- Retention of food nitrogen for building new tissues.
- Better heat regulation and other skin reactions.
- Increased gastric secretion and increased appetite.

The stimuli are :

- Either sun's rays, or
- Wind and cold air.

These stimuli affect the skin, and hence the most sheltered climate is obtained by the use of heat in our homes, or by clothing out-of-doors. Each one can fashion his own climate.

Dr. M. B. RAY.—*Climatic sensitivity* (11.45).

Some preliminary consideration is given to certain climatic factors—temperature, radiation, atmospheric pressure, humidity and ionisation—which exert an influence on the bodily health.

Environmental changes thus induced are registered by the skin which has a correlation with an intricate mechanism involving the blood, nervous system and hormones of the body.

The stability of the internal economy of the organism in the face of atmospheric variations is maintained by an autonomic adaptation affecting the chemistry of the blood and tissues, the acid-alkali balance, the gaseous exchange and the state of the endocrine glands.

Atmospheric disturbances involve periods of stimulation which for the majority of normal individuals pass unnoticed. According to Peterson's observations on the comparison of the records of barograph readings with those of systolic and diastolic blood pressure in normal subjects, systolic peaks coincide with a rise in barometric pressure or the beginning of a fall, the diastolic pressure being low after this peak. In a normal individual this rhythm does no harm, and if the climatic changes are sufficiently frequent and intense, good will be done by the increase in the adaptative powers.

On the other hand, in the old and feeble, where the powers of adaptation are inadequate, repeated atmospheric variations have an adverse effect.

GENERAL DISCUSSION (12.30).

## Tuesday, September 15.

DISCUSSION on *The strain of modern civilization* (10.0).

Rt. Hon. Lord HORDER, K.C.V.O. (see page 464).

Dr. R. D. GILLESPIE.—*Modern civilization in its relation to nervous and mental breakdown* (10.30).

Dr. E. P. POULTON.—*The strain of modern civilization* (11.0).

There are two opposing factors in the strain of modern civilization. The first factor, which increases the strain, is the rise in the standard of living. The second factor, which should diminish it, is that the luxuries as well as the necessities of life are requiring fewer people and shorter hours for their manufacture, so that there is more spare time available. The fault lies in (1) failure of distribution, (2) defective education, so that those who have the spare time are often unable to profit from it.

The medical or medico-sociological aspects of the strain of modern civilization cover an enormous field. I shall confine my remarks to certain general effects that concern us all.

In England and Wales the last time 'the net reproductive rate' was above 1 was in 1925; but the rate has been reckoned in 1933 as not much above 0.75 (Enid Charles). The average family must contain 3.1 children of both sexes to make a stationary population. The strain of modern civilization with the inducements towards an even more luxurious standard of living among the middle classes must be held responsible for this falling population.

Diet of growing children.—The children of the poorer classes are shorter than those who are better off; and yet, when we examine the relation of the height and weight, which is the index of general nutrition, we find that it is the same for all classes. Now the converse has been found in the case of horses which have been insufficiently fed (Brody).

In adults the tendency is to overfeed. We are far from believing that every obese person has merely taken more than is warranted for by his appetite; but all these obese people have taken more food than their bodies have been able to deal with by combustion. The associated increased metabolism means that more work is thrown on the circulation and obesity is a well-known predisposing cause of diabetes and possibly diseases. Standards of normal weight must be considered. Most people tend to put on weight as they become middle-aged. Is this physiological, or should a man of fifty preserve his youthful weight and figure?

Tobacco and alcohol are also considered; the effect of the latter is particularly important in motor driving in view of increased reaction time after quite small doses. The amount of a beverage that is usually taken, e.g. a glass of cider, beer, sherry, etc., contains roughly the same volume of alcohol (10–20 c.c.). The variability of the content of alcohol in a cocktail is its disadvantage.



Miss E. M. KILLICK.—*Some health hazards from toxic substances in modern industrial civilization* (11.30).

The occasions of exposure to toxic gases and fumes are described, and the possible harmful effects of long-continued exposure to such gases in concentrations too low to cause acute effects are discussed.

Carbon monoxide is an important example of the type of toxin under consideration since it is a constituent of the exhaust fumes from petrol engines, and also of illuminating gas, in addition to occurring as a by-product in many industrial processes.

The results of prolonged exposure to very low atmospheric concentrations of carbon monoxide are described under two headings :

- (1) A state of continuing vague ill-health ;
- (2) The development of acclimatisation to the gas.

The importance of this prolonged exposure to very low concentrations of toxic gases is considered as a factor in reducing the normal reserve capacity of the body to respond to unusual strains.

Other toxic substances, such as oxides of nitrogen and the fumes of volatile organic solvents, are considered from a similar point of view.

GENERAL DISCUSSION (12.0).

## SECTION J.—PSYCHOLOGY.

Thursday, September 10.

Prof. F. A. E. CREW.—*A repetition and re-examination of McDougall's Lamarckian experiment* (10.0).

In order to be in a position to examine the conclusions which Prof. McDougall has reached, eighteen generations, comprising 1,445 experimental and 1,014 control rats, have been trained, and the figures provided by these are compared with those which McDougall derived from twenty-one generations of rats of the same origin. The average number of errors per rat made by the individuals of the tank-trained stock has not decreased with the passing of the generations ; there is no difference whatsoever between the scores of the experimental and control stocks. No evidence was forthcoming which would suggest that rats of the two stocks may be distinguished one from the other by differences in behaviour. Analysis of the pedigrees shows definitely that genetic factors are heavily concerned in the establishment of the scores. The parent-offspring correlation is 0.3. A 'quick' strain has been developed as the result of consistent favourable selection. Amongst my rats there is a great excess of those which tend to leave the tank habitually by one route during the first phase of their training when the light is constant and equal on both sides of the tank and when the platforms are not alive. Furthermore, no fewer than twenty-nine experimental and ten control rats, having reacted to the light as light in the second phase of their training when the light was alternating but the platform was not alive, actually learned without receiving a single shock.

Mr. C. Fox.—*Mental heredity* (10.45).

Human mental heredity should be considered independently from physiological heredity. In the latter the inheritance depends on agglomer-

ations of genes ; but for mental inheritance there are only certain potentialities, not material things. It is like taking over the goodwill of a profession which consists of reputation alone. We inherit only the ability to acquire ability. Galton's researches led to the idea of certain superior human stocks whose mental nature was independent of nurture. But more thorough analysis shows that, even for identical twins, mental resemblances are overwhelmingly dependent on nurture. Similarly, temperamental differences and other personality traits are conditioned almost entirely by patterns of culture. This is established by the study of primitive peoples, where the traditional temperamental differences between the series of civilised societies do not hold, and may even be reversed. As for 'racial' inheritance the term 'race' is no longer applied to human aggregates by anthropologists who know their own business. Differences between different nationalities are the results of history, tradition and culture. Even the supposed ineducability of negroes is largely the result of prejudice, and is not borne out by the latest objective evidence, that of mental tests. Still less is there any scientific evidence whatever for the comparative superiority of intelligence of any European people over any other.

Dr. W. BROWN.—*Freedom and moral obligation in the light of modern psychology* (11.30).

Dr. W. STEPHENSON.—*Type psychology* (12.15).

#### AFTERNOON.

Dr. M. M. LEWIS.—*The beginning of reference to past and future in a child's speech* (2.0).

Although a good deal of attention has been paid to the manner in which grammatical forms arise in children's early speech, very little account has been given of the manner in which new *functions* become differentiated. In this paper an attempt is made to describe the growth of two of these functions : reference to the past and to the future.

The occurrence of either of these two functions is of great importance in the child's linguistic growth—for with this advance the child's speech begins to be freed from the dominance of the present situation. But in neither case is there a sudden step, as has sometimes been suggested. In the present paper several series of observations of a particular child are considered, and in this instance it is shown that reference to the past and to the future arise as the result of social intercourse acting upon the child's needs, in the following manner :

1. (a) At an early stage the child's needs cause him to make rudimentary reference in his speech to absent objects ; (b) he also responds, by his acts, to references that others make to absent objects.

2. Linguistic intercourse begins : the child learns to respond to speech by speech.

3. Persons addressing the child will constantly refer to some past event ; and both the words spoken to the child and his recall of the past event will tend to evoke some remark from him. Speech of this kind will gradually come to refer definitely to the past.

4. The child's needs cause his activities and accompanying speech to be forward-directed ; when at such a moment someone addresses the child, his reply will tend to take on a more definitely future reference.

5. Ultimately the child comes to refer spontaneously to the past and to the future.

Dr. RUTH GRIFFITHS.—*The significance of phantasy in the normal development of childhood* (2.45).

Phantasy activity is regarded as characteristic of early childhood. It is common to all children and a normal manifestation. It represents a transition phase between infancy where physical learning is more prominent, and the later more intellectual development.

A study of children's phantasies goes to show that childish thinking is not dissimilar from that of adults. It conforms to the neogenetic laws and has many other characteristics of adult thought. The intense emotional experience of this period coupled with its lack of knowledge of the external world gives to the child's thinking its peculiar tone. Phantasy is here regarded not so much as an avoidance of reality but as a means whereby the child masters in a piecemeal fashion the problems presented by his environment and circumstances.

The function of phantasy is to undertake the resolution of a problem conceived at the conscious level but requiring *time* for its understanding. Symbolism is often employed. The method is indirect, working from a central egocentric attitude gradually towards a more socialised and objective one. The result of the process is found both in the acquisition of information by the subject as well as in this change of mental attitude.

Miss D. M. DALDY.—*A study of adaptability* (3.30).

This study was made with a group of thirty-one domestic science students in connection with their training in teaching.

*Method.*—Students were studied as individuals primarily, and discussion of personal interests and difficulties, etc., resulted from criticism of work. Intelligence tests were given, and home conditions considered, though inadequately. The teaching ability of each was analysed into selected 'teaching factors,' and a literal mark indicative of ability was awarded and checked by independent observers. Students were graded as well- or ill-adapted according to their powers to adjust adequately to a situation without (1) undue emotional strain; (2) disproportionate displays of emotion; (3) production of conflict or friction in the environment. Tables showing the distribution of adaptability and teaching ability to each 'teaching factor' and to home conditions and intelligence were made.

Results :

- (1) Seventeen students were ill-adapted; fourteen well-adapted.
- (2) Intelligence alone did not determine teaching ability.
- (3) Difficulty in adaptation affected teaching ability adversely.
- (4) Ill-adapted teachers were handicapped especially by inability to :  
be definite; concentrate; order sense impressions; react quickly to stimuli; make contact with their pupils; arouse interest.
- (5) Over-facility in adaptation handicapped teachers.

### Friday, September 11.

PRESIDENTIAL ADDRESS by Mr. A. W. WOLTERS on *Patterns of experience* (10.0).

DISCUSSION on *The psychology of mass entertainment* (11.0).



Mr. DENYS W. HARDING.—*The desire for entertainment.*

A questionnaire responded to by some two hundred people, chiefly workers attending adult educational classes, yielded information on (amongst other matters) the psychological conditions in which the desire for entertainment is most strongly felt. These fall into three strikingly different classes: (a) tiredness after work, the emotional state not being especially noticeable; (b) unpleasant emotional states (boredom, depression, irritation, strain, etc.); and (c) states of elation, cheerfulness, energy, and euphoria generally. The relations between these different conditions are examined, and the kinds of entertainment that cater for them discussed. Several considerations suggest that a feature common to the entertainment demanded in all three states is that it should offer an *immediate and direct* reward for the effort (whether great or small) that it requires. This is its unflinching contrast with almost all modern work. The view that entertainment is a form of 'escape' appears to have only a very limited validity. Another important aspect of the desire for entertainment is its connection with the individual's social life; the relationships between the two are complex and various, and the material here presented throws some light upon them.

Mr. F. C. THOMAS.—*Basic mental mechanisms concerned in mass entertainment.*

The field of mass entertainment to be discussed is limited to the types of organised and commercialised amusements, typical of the modern fair-ground, amusement park, or pleasure beach.

(i) Mass entertainment as a means of giving expression to certain of the 'innate propensities' described by McDougall:

(a) On the normal level.

(b) On the slightly pathological level, the same propensities being expressed in aberrated form, as regressions, fixations, compensations, displacements, etc.

(ii) Theories of play and laughter.

(iii) The roles of suggestion and imitation.

(iv) The personal and social value of such types of entertainment.

Rev. F. A. FARLEY.—*The psychological types to whom mass entertainment appeals.*

To what psychological types do the patrons of mass entertainment belong? We begin from the fact that they like a crowd, and that the presence of the crowd is an essential part of their enjoyment. They are gregarious; but it is not enough to say that they are those in whom the gregarious impulse is strong. That would be an explanation only if we could assume a gregarious instinct in man, and that is called in question. The real classification is not into those more or less gregarious but into those of extrovert or introvert tendency. This covers other classifications proposed, e.g. that into surgent and desurgent types. Mass entertainment must look to those of extrovert tendency for its patrons, and it will also encourage the extrovert tendency.

The psychological characteristics associated with extroversion are examined and certain conclusions are drawn as to the social and personal effects of mass entertainment.

It is suggested that during adolescence the previously prevailing tendency undergoes modification, and extreme extroversion or introversion may then be corrected. What effect has the provision of mass entertainment on this desirable process during adolescence?

#### AFTERNOON.

Dr. B. SEMEONOFF.—*The discrimination and estimation of loudness* (2.0).

A survey of work on the application of Weber's law to sound intensity, from the earliest to the most recent investigations, shows an overwhelming balance of evidence against the constancy of the 'Weber-Fechner fraction.' The variation in value seems to be continuous over the intensity range. Practically all investigators have found an increase in the value of the difference threshold at low intensities, and a rather smaller increase has often been found at high intensities.

Fresh experiments, carried out with a 512-cycle valve-maintained tuning-fork at nine intensities (roughly 25–105 db. intensity level) yielded similar results. Large individual differences were found, and also considerable day-to-day variation.

The relation between stimulus and sensation may also be studied by a more direct method—the estimation or judgment of loudness in absolute (subjective) units. Previous investigations have usually yielded consistency within their own bounds, but not with the results of other researches. This was confirmed in a series of experiments using the above-mentioned apparatus. It may be concluded that different formulations of the stimulus-sensation relationship are necessary for different observers, and that these functional relationships may be of fundamentally different mathematical forms.

Mr. W. F. TYLER.—*A means for the comparison of hot climates* (2.45).

Our sensation reactions to climatic conditions in hot countries cannot be ascertained from meteorological tabulations alone. What is needed for the purpose of comparing those reactions at various places is a sensation scale of degrees of climatic discomfort correlated to meteorological factors. An investigation at Shanghai by the writer in 1904, conducted in natural conditions, produced such a scale within the limits of humidity from saturation to 60 per cent.

The usual way of forming a sensation-scale from least observable differences was obviously impracticable, and the writer had in consequence to use the method of estimates of degrees of discomfort interpolated between two defined limits. As a lower limit the beginning of discomfort was satisfactory, but for an upper limit an imaginary unbearable condition had, in the absence of something better, to be adopted. Notwithstanding the defect of that upper limit and the uncertainty regarding the ability to interpolate degrees of sensation, the estimates of twelve observers over a period of a month resulted quite definitely in the establishment of a relationship between degrees of discomfort on the one hand, and temperature and humidity on the other, with air-movement as a constant.

This sensation scale covered—owing to the limits of the range of humidity at Shanghai—only about a third of the full range of humidity. Without an extension of it to the limits of aridity, a comparison of climates generally cannot be effected. A further psycho-physical investigation to obtain that



extension is unlikely for a long time to come. Consequently the writer offers an approximation to it by a certain line of argument.

It is considered that the total sensation reaction to tropical and sub-tropical climates is made up of two parts : one, which can be named physical, tends to be marked by such physical signs—in the medical sense—as varying degrees of perspiration ; the other is a neural reaction ranging from lethargy in humid conditions, through varying degrees of exhilaration in moderate humidity, to excitement and irritability in arid conditions.

The writer's idea is that for various places a mean of daily temperatures and humidities at, say, noon be obtained, that these be converted to degrees of physical and neural reaction by his method, and that the results be plotted in diagram form for the purpose of comparison.

An example of such a comparison between two places is provided.

Dr. S. J. F. PHILPOTT.—*Resemblances between fluctuations in curves of mental output and of chemical change* (3.30).

It is suggested that fluctuations sometimes found in curves of chemical change are of the same nature as those met with in curves of ' fluctuation of attention.'

Attention waves are geometric in the sense that times at which successive crests (or troughs) occur are in geometric progression. They thus seem to have constant period when plotted against the log of time. All log periods are whole number multiples of 0.0016. Phase also is constant, all trough sequences converging on a common trough at the time

$$T_0 = 4.076 \times 10^{-23} \text{ seconds}$$

There is no predicting when any given wave will appear. As it were, the person concerned takes a random handful from a pool of possible elementary waves with which to constitute his curve of any given experiment. The most obvious periods in a curve are apparently of repeat cycle significance. That is to say, they tend to be highly factorisable multiples of the unit, as, e.g., 108, 180, 252, etc. So that although no two curves are ever alike in minor detail (depending as they do on randomly chosen elementary waves), there are nevertheless but few major measures in practice, namely the highly factorisable periods just mentioned.

Certain chemical curves are presented, the reaction being that of normal hydrochloric acid on aluminium in the presence of platinum and a trace of gelatin. No two are alike in minor detail, but the measures made are those commonly occurring on the mental side, whether in respect of period or trough sequences. It seems clear that the unit of periodicity, the common trough point, and the element of random sampling hold both for mental and chemical fluctuations.

Dr. T. G. MAITLAND.—*Visual factors of vertigo* (4.15).

When our equilibrium breaks down after certain kinds of imposed movement, such as being turned in a revolving chair, it is the failure of the kinetic and postural attempts at compensation which cause 'special' vertigo. The subsequent illusion of subjective or objective turning that characterises this type of vertigo is largely due to the persisting 'to and fro' movement of the eye, called 'ocular' nystagmus.



General vertigo is distinguished from special vertigo by the absence of this illusion of turning ; in its place there is an illusion of recession and approach or undulating of objects in the visual field. This illusion is due entirely to a condition of ocular imbalance with its constantly recurring efforts at focusing.

Inasmuch as these examples of vertigo are extremely complicated in their somatic causes, the third type of vertigo offers a simpler example for analysis.

It, also, is characterised by an illusion of movement of objects, and sometimes of oneself, not very dissimilar from that of special vertigo, but is never severe and is always of short duration. In this case the cause is entirely visual. When a uniform succession of objects moves across the field of vision, sufficiently monotonous not to excite close attention, the eyes will react by 'optic' nystagmus. If this succession of passing objects continues sufficiently long, there is left a residual and persistent nystagmus after the objects have passed out of the line of vision. The illusion which then ensues is an apparent movement of the stationary background, and a momentary sense of vertigo.

Another type of post optic nystagmus bearing a close relation to the last is miner's nystagmus. The excitation is also visual, the conditions for its persistence are also those of mental distraction. The difference is that both components of miner's nystagmus are fast, i.e. fixation reflexes.

### Monday, September 14.

Dr. R. W. PICKFORD.—*Conclusions of a study of group psychology* (10.0).

This paper deals with some results of an attempt to approach the history of painting from the points of view of the biology and psychology of groups. A strictly scientific treatment of advanced cultures along these lines has not often been attempted. The phases of the history of painting which have been studied are : Barbizon and Glasgow groups, Pre-Raphaelites, Mogul miniature painters, Bushman art, the Russian icon and the work of Chardin, Goya, Daumier and Cézanne. The following points are discussed : transmission of culture by group contacts, borrowing and grafting, and the omissions involved in these changes ; constructiveness, conservation and decay in group life. It is interesting to find that these changes take place in advanced cultures in much the same way as they do in primitive cultures.

DISCUSSION ON *The reform of the examination system* (10.45).

Dr. LL. WYNN JONES.—*The reform of the examination system.*

One stream of criticism by practical schoolmen has been directed against the pernicious effects of examinations on curricula, and hence on 'culture'—which is an ambiguous term and is moreover in a state of flux. Reformers of curricula have usually to expect small profits and slow returns, *cf.* the need of psychological background for would-be clergymen, physicians, and lawyers. The other stream of criticism by psychological testers is concerned with the content and form of examination papers, errors of marking, or failures to take into account variations in the performances of individual candidates. Here, also, the carrying out of essential reforms shows a lag.

The following observations may be formulated :

(1) There is a great need of a sufficient number of psychological testers adequately trained in the technique of examining. Concrete examples of pitfalls to be avoided are cited.

(2) Standardised tests of intelligence, of English, and of arithmetic, should be universally employed as means of selection for scholarships to secondary schools. At present, only a small percentage of local educational authorities employ all these means. Moreover, methods of selection not vouched for by experts should never be employed.

(3) There is the need of large-scale researches (such as those initiated in Leeds a year ago) in order to compare the prognostic values of tests of intelligence, tests of special abilities, tests of attainment, teachers' estimates, school records, etc.

Prof. H. R. HAMLEY.

Mr. W. A. F. HEPBURN.

The network of examinations which binds together and gives design to modern educational activity is the end-product of a traditional device which, originating in a felt need and to serve a specific purpose, has been adapted and extended to meet new needs and serve other purposes. Since the device as a measuring instrument is now known to be fallible and because the circumstances in which it is used grow in complexity yearly, there is a call for revaluation and reform. Among other considerations regard should be had to the following : the statistician's disclosure of the unreliability and invalidity of the traditional written examination ; the need, consequent upon a more complete psychological analysis of the situation, of new ways of ascertaining the facts of achievement and the indications of promise ; the extent to which the objective of the examination should prescribe the nature of the test ; the effect of the examination system upon the aims of teaching and the content of instruction ; the need to subordinate the examiner to the ends to be served by the educational process ; the search for quality in human beings and the importance of guiding the examinee rather than accepting or rejecting him ; the significance of the teacher's opinion ; the dangers of authoritarianism and the urgent need of research.

Prof. J. DREVER.

It is of the first importance that we distinguish the different types of examination, since it is obvious that different principles will apply in the different cases, according as examinations are intended to be progress indicators, qualifying examinations, or competitive examinations. Unless the examiner has this distinction clearly in mind the examination may fail to secure the purpose it is meant to secure.

The evil may not stop there. The whole education of the pupil or student may be warped by a distortion of his values arising out of the development of a wrong attitude towards examinations. Educating for examinations and not for life is a defect unhappily far from unknown in our national education, both school and university. This will be an inevitable outcome of an excessive emphasis upon examinations, which in turn will tend to be an indirect result of applying the principles, say, of competitive to qualifying or progress examinations.



## AFTERNOON.

Dr. HILDA W. OLDHAM.—*A psychological study of mathematical ability* (2.0).

*The Problem.*—An investigation of school mathematics, mainly with the object of discovering by scientific method whether or not it is justifiable to include arithmetic, algebra and geometry as one group for school certificate and matriculation examinations.

If arithmetic, algebra and geometry are separate and distinct abilities, then they should be regarded as such for the purposes of school examinations.

*The Method of Research.*—A questionnaire was sent to teachers of mathematics in different parts of England to ascertain their opinions concerning these differences in mathematical abilities. A statistical investigation was then conducted. Tests in arithmetic, algebra, geometry and general intelligence were given to children in fourteen different schools. In all, four hundred and ten children were tested. The results of these tests were correlated and partial correlations were worked out. Professor Spearman's criterion of the tetrad difference was applied. Conversations were held with the children examined, and their subjective attitude to the tests and to mathematics generally were obtained.

*Results.*—There seemed to emerge no group factor big enough to justify the inclusion of arithmetic, algebra and geometry in one group for purposes of school examinations.

In some sets considerable group factors appeared but seemed to be due to extraneous influences, and not to be connate and intrinsic to the activities involved in the abilities concerned.

Mr. R. J. BARTLETT.—*Amnesia—a case study* (2.45).

Invalided from work under a diagnosis of 'early G.P.I.' and having passed through three other institutions, a man of 52 was admitted to Bethlem Royal Hospital in January, 1935, in a badly disorientated condition. He was discharged in January, 1936, able to return to his family and assist in the work of a small shop.

Pathological examination negated the G.P.I. diagnosis, neurological examination failed to secure a satisfying diagnosis and psychological examination indicated that the disorientation was not due to delusion or imperception but entirely to amnesia.

In the resulting treatment memory work played an important part. This work consisted of:—

- (a) Patient conversational recovery of recent events,
- (b) Retracing previous walks and recovery of incidents therein,
- (c) Laboratory work with outline drawings.

The work showed, in highly exaggerated form, well-known difficulties and errors in learning, recall and recognition, and progress was very slow and interrupted from time to time by marked plateaux.

The case is given as an example of successful collaboration of experimental psychology and medicine in the treatment of an apparently hopeless case, for, whatever the ultimate results may be, there has been at least a temporary alleviation of a very serious maladjustment to environment.



Mrs. F. M. AUSTIN.—*Some examples of suggestibility in university students* (3.30).

- (1) The power and subtlety of suggestion.
- (2) The facts that when suggestion is accepted
  - (a) conscious reasoning may be absent altogether ;
  - (b) acceptance may take place in spite of the fact that the subject is aware of what seems to him to be overwhelming evidence against the suggestion ;
  - (c) reasoning may reinforce suggestion.
- (3) Mal-perception, mal-interpretation, elaboration and supplementation.
- (4) Influence of
  - (a) reluctance to admit ignorance ;
  - (b) desires ;
  - (c) preconceived ideas.
- (5) Contra-suggestibility.

Mr. T. A. RODGER.—*A critical review of the present position of vocational psychology in Great Britain* (4.15).

This paper is concerned mainly with psychological procedures at present in use in vocational guidance work in this country, but some consideration is given to problems of vocational selection, and to the relationship between vocational guidance and vocational selection.

The vocational guidance procedure adopted by the National Institute of Industrial Psychology is reviewed, and some of its potentialities and limitations commented upon. Data are provided concerning the types of individual who, at the present time, seek the vocational adviser's help.

The development of careers advisory work in schools is discussed, and some suggestions made concerning the characteristics which the vocational adviser might profitably possess, and the sort of training he might profitably undergo.

Some major research problems are outlined, and the desirability of enlisting the aid of university and other organisations in the search for the solution of them is stressed. It is urged that, during the next few years, considerable attention should be paid to the analysis of occupational requirements.

## Tuesday, September 15.

Dr. E. J. LINDGREN.—*Methods of investigation in social psychology* (10.0).

Methods of investigation in social psychology are concerned with either (i) the collection, or (ii) the analysis and interpretation, of data on social behaviour. At the present stage of development of this branch of study, more attention might profitably be paid to the problems raised by (i) than to those involved in (ii), which have already inspired many stimulating hypotheses.

Social data may be collected by means of (a) the study of records, ranging from census reports and legal proceedings to advertisements and folk-lore ; (b) psychological tests and experiments, conducted in schools or laboratories under controlled conditions ; (c) interviews and questionnaires, which permit subjects to remain in a non-artificial social context, but still entail partially controlled conditions ; and (d) the observation of subjects acting under 'natural,' i.e., entirely uncontrolled, conditions, by a relatively passive investigator who as far as possible avoids disturbing the culture in any way.

Anthropologists studying primitive peoples have acquired valuable experience in the application of method (*d*), which is often the only one open to them. When psychologists have critically examined the practice and implications of current anthropological field technique, it should yield important results in the social psychological investigation of more complex cultures.

Mr. C. A. OAKLEY.—*Some of the psychological problems of a depressed area* (10.45).

This paper is in three parts, dealing with: (*a*) the characteristics of the jobless worker; (*b*) the effectiveness of different plans for occupying his time and interests; (*c*) the difficulty of getting him a new job.

Fundamental in the attitude of the unemployed workers to-day is irritation at being thwarted in their accustomed forms of creative expression and of general living. During their first period of unemployment, they are also in a state of fear, but apathy often follows. They are unable to say how they have passed their time. Interest is lost in politics. Religion is treated in different ways, some workers turning to it and some scoffing at it. Old feuds are forgotten but petty quarrels sometimes flare up. Their affectional relationships are undermined. The school work of their children deteriorates. References are made in the first part of the paper to published studies of unemployed workers in other countries such as the United States, Italy and Austria. The second part is based upon views expressed to the author by persons engaged in community service work. The third part deals with the cumulative psychological effects of 'bad times' on owners of factories as well as workers, and with the difficulties of attracting new industries to depressed areas.

CO-ORDINATED SOCIAL RESEARCHES IN A SCOTTISH AREA (11.30).

Dr. O. A. OESER.—*Methods of empirical research in social psychology.*

A survey of past systems of social psychology and of efforts made to measure social forces and behaviour is followed by an analysis of the methods in use by, or adaptable from, experimental psychology, sociology and ethnology.

The synthesis of methods is justified and illustrated by a survey of the field work in social psychology now being carried out in a Scottish industrial city by a research staff consisting of psychologists trained in different branches, an economist-historian, and a medical psychologist. The central problem is *The Psychology of Juvenile Unemployment*. This is shown in its complex social setting in an industrial city. Some results of the preliminary descriptive survey and of the functional penetration of the field are discussed.

Mr. H. HILLMANN.—*The relation of economics to social psychology* (12.15).

The complexity of modern society may be well reflected in a particular industrial area. To cope with the problems which arise when the attempt is made to disentangle that complexity is the task of economists, sociologists, psychologists, and other social scientists. In the realistic study of a Scottish area the purely economic approach encounters certain factors the neglect of which would limit the validity of the findings of the economist and not

reflect the true picture of social reality. As the industrial area under consideration is subject to evolutionary transformation, it is necessary to indicate the kind of problems which cannot be explained in terms of economics. The economist has to make certain assumptions as to the constellation of the social data. From his point of view, he considers it the task of the other social sciences to provide him with more adequate information as to the implications of his economic assumptions. An attempt is made to show how closer co-operation of social scientists might lead to explaining with greater validity the social complexity of an industrial area.

Mr. W. O'D. PIERCE.—*A new approach to vocational psychology with empirical data on job changes (2.0).*

The underlying assumptions, attitudes, and methods employed by British vocational psychologists were compared and contrasted with the attitudes and methods of German and American vocational psychologists. Vocational psychology cannot be regarded as vocational guidance combined with industrial psychology. Vocational psychology can be a positive science which aims at describing and measuring the attitudes and behaviour patterns which arise during the industrial life of the individual as well as the individual and group behaviour in emotionally toned industrial situations. The industrial social data, after collection by a team of field workers, is then analysed by statistical means to show the various differential occupational patterns existing and their relationship to other social patterns.

The empirical data presented consisted of the analysis of changes in occupations occurring in the period July 1, 1934, to July 1, 1935, as recorded in Juvenile Employment Bureau. An occupation change includes return either to the same or to a different job inside the period mentioned. The main results may be summarised as follows.

| Industry.                     | No. in Group. | Per cent. Changers. | Jobs Held per Individual. | Jobs Held per Changer. |
|-------------------------------|---------------|---------------------|---------------------------|------------------------|
| Jute . . . . .                | 188           | 42.6                | 1.88                      | 3.08                   |
| Distributive trades . . . . . | 94            | 22.3                | 1.39                      | 2.76                   |
| Preserves . . . . .           | 29            | 37.9                | 1.76                      | 3.00                   |
| Printing . . . . .            | 20            | 39.9                | 1.60                      | 2.50                   |
| Engineering . . . . .         | 11            | 9.1                 | 1.09                      | 2.00                   |
| Building . . . . .            | 6             | 0.0                 | 1.00                      | 0.00                   |
| Remaining trades . . . . .    | 56            | 48.2                | 1.96                      | 3.00                   |
| Total and Averages . . . . .  | 404           | 36.7                | 1.72                      | 2.98                   |

The jobs held per changer with age were 14-15 years 2.81; 15-16 years 3.23; 16-17 years 2.58; 17-18 years 2.79.

The data clearly shows that differential occupation job change patterns occur in different industries. The figures show that while approximately 8,500 jobs were available for juveniles, the job changers, who number 36.7 per cent. of this juvenile industrial population, held over 9,300 jobs inside a one-year period. Flow sheets of job changes between different occupations and industries were also presented.

The significance of this data and their relationships to the problems of vocational guidance inside a comprehensive study of the vocational psychology of an industrial area was outlined.



Dr. HELEN PALLISTER.—*The relation of vocational psychology to social psychology* (2.45).

Vocational psychology and social psychology are closely related since both these branches of psychology frequently deal with data of the same kind. In order to provide adequate vocational guidance or selection, the vocational psychologist must be acquainted with findings concerning a number of factors studied by the social psychologist. Among these factors are : interests and attitudes, especially attitude towards work and the social values of different occupations, intelligence level, educational status, sex differences and age differences. Such factors delimit the field within which the vocational psychologist can function effectively.

Some of these factors are now being studied. An analysis has been made of empirical data from cards filled in by approximately 1,000 juveniles, 14 to 16 years of age, for the Juvenile Employment Bureau of a Scottish industrial city. The factors studied are : vocational preferences of the juveniles, school courses pursued, educational status, intention to attend continuation classes, club membership and interests. The relation of the vocational preferences to these other factors is reported.

The follow-up of the vocational life of this group will be undertaken and the relation of the occupations obtained to the vocational preferences expressed will be reported in due course.

Mr. E. L. TRIST.—*The functional penetration of a social field* (3.30).

A way of overcoming inaccessibility of data in social psychology is for the psychologist himself to play various rôles in the community under study. Rôles adopted by the investigators in Dundee. An attempt through the utilisation of these rôles to determine empirically the local form of attitudes. On the results of indirect questionnaires constructed on the basis of these local forms, the possibility of mapping, systematically, the attitudinal setting of individuals in different groups. The correlation of the attitudinal setting with the industrial and institutional setting.

The characteristics of this relationship give a picture of the principal social patterns in the community, alike in terms of behaviour and of economic and cultural structure. The scope of such patterns in Dundee ; differences in flexibility and rigidity, in interdependent and independent functioning.

Unemployment as a disturbance of the social type of the individual. The influence on reactions to it of some special Dundee patterns. The social elaboration of age and sex as factors imparting different valencies to the situation at different life periods in the two sexes.

## SECTION K.—BOTANY.

Thursday, September 10.

PRESIDENTIAL ADDRESS by Mr. J. RAMSBOTTOM, O.B.E., on *The uses of fungi* (10.0).

Prof. F. E. FRITSCH, F.R.S.—*The life-cycle of the Lower Brown Algæ* (11.0).

The communication brings no fresh facts, but presents a somewhat new interpretation of the available data. Consideration is restricted to the

Ectocarpales as delimited by Oltmanns. The life-cycle in these forms, apart from a limited number of exceptional types, is to be regarded as comprising an alternation between diploid and haploid phases, isomorphic in the simpler filamentous types, heteromorphic as a rule in the more advanced forms. The diploid phase in the latter is constituted by the elaborate macroscopic thallus which bears either unilocular sporangia only or plurilocular ones as well, the latter being then most commonly produced at an earlier stage than the unilocular sporangia. The haploid phase is a small filamentous plant bearing plurilocular sporangia (i.e. gametangia) only. Either phase can propagate for several generations by means of small ectocarpoid stages, the diploid one doing so by means of the swarmers from the plurilocular sporangia which give rise to plethysmothalli (using Sauvageau's term in this sense only), the haploid one by means of apogamously developing gametes which give rise to accessory gametophytes (*not* plethysmothalli). The plethysmothalli as above defined are to be regarded as arrested (juvenile) stages of the sporophyte whose general resemblance to the haploid phases is a result of the derivation of the two generations from the isomorphic or homologous type of alternation seen in the simpler representatives (Ectocarpaceæ) of the group. The succession of plants formed from the diploid swarmers of the plurilocular sporangia of an *Ectocarpus siliculosus* or other simple type are the equivalents of the plethysmothalli of the higher forms. How far the life-cycle above indicated can be short-circuited by the fusion of swarmers from the unilocular sporangia remains to be seen.

Prof. Dame HELEN GWYNNE-VAUGHAN, G.B.E., and Mrs. Q. E. BROADHEAD.—*Methods of reproduction in Ceratostomella fimbriata, the cause of mouldy rot of the Para rubber tree* (11.40).

This fungus is self compatible with a mycelium of uninucleate cells, bearing chlamydospores and endoconidia, both of which germinate readily.

The perithecium has two zones of wall cells and an internal lining of turgid cells forming a cushion. The neck arises from the inner zone of the wall; it is made up of thick walled, parallel hyphæ, lined by delicate filaments.

The ascogenous hyphæ arise from a multinucleate cell. No antheridium is present and development is apogamous, the only nuclear fusion being that in the ascus. The haploid number of chromosomes is three, there are three gemini in the prophase of meiosis which is the only reduction phase in this life history.

Prof. B. NĚMEC.—*Gold and other rare elements in plants* (12.20).

On analysing ashes of seeds and seedlings of corn from Oslany (West-slovakia) we found in the ash some elements until now only rarely discovered in plants, such as gold and titanium. This discovery led to the study of the ashes of other plants from the same locality. In *Equisetum*, gold has been found in comparatively large amounts, and in the wood of *Fagus*, *Carpinus* and other species, in addition to gold, aluminium, titanium, copper, zinc, vanadium and chromium have been found. We have found the same elements in *Polyporus fomentarius* growing on *Fagus* and *Carpinus*.

Cultures of corn seedlings have shown that gold has a slight stimulating effect upon growth.

AFTERNOON.

Excursion to Garstang district.



### Friday, September 11.

Dr. C. E. FOISTER, Mr. I. W. TERVET, and Mrs. N. L. ALCOCK.—*A contribution to the study of rots in potato storage* (10.0).

A storage rot of potatoes much resembling Dry Rot (*Fusarium cæruleum*) but caused by a pycnidial fungus has recently been investigated. The early symptoms of the disease consist of small depressions, the later stages of large, intact or wrinkled areas. A large internal rot develops, often with large cavities which are lined with mycelium in which are embedded the black pycnidia. Using single spore cultures, the disease has been produced in various commercial potato varieties. Early varieties are more readily affected and the disease is more prevalent in boxes or bags than in clamps. The disease has been present for a number of years but its resemblance to Dry Rot has caused it to be classified as the latter disease. The fungus belongs to the *Phomaceæ* and is possibly new to science.

Dr. J. CALDWELL.—*Recent work on the nature of virus* (10.30).

The aspect of the problem of virus diseases in plants which has been most studied recently is the nature of the causative agent of the disease. A crystalline protein has been shown to be associated with the disease of Mosaic of Tobacco (Tobacco Virus I) and attention has been focussed on the relation of this protein to the agent of the disease. The mode of infection with the virus of this disease has been re-examined and evidence is adduced to support the view that infection by means other than through broken protoplasts is rare. The age of the leaf at the time of inoculation and the amount of growth made by the leaf at the time of inoculation are of primary importance. A method is discussed which allows of the study of the effect of substances on the virus without confusion with the effect of these substances on the host tissues.

Dr. M. NOBLE.—*Heterothallism in Typhula Trifolii* (11.0).

In *Typhula Trifolii* the haploid hyphæ have plain septa and usually one nucleus in each cell, the diploid possess clamp connections at most of the septa and usually one pair of conjugate nuclei in each cell. Anastomosis and migration of nuclei occurs in haploid and in diploid mycelia where there is no question of diploidisation.

Monospore cultures sometimes produce haploid sclerotia and fructifications. The latter are smaller than the diploid and produce small fertile spores.

When anastomosis occurs between compatible haploid mycelia, migration of nuclei takes place followed by upsetting of the equilibrium of the cells of the invaded hypha, in which some of the indigenous nuclei disintegrate. Nuclei migrate by the partial or complete dissolution of the transverse septa; where partial dissolution takes place half walls are produced and at these the side wall may bulge out. When the invading nuclei have reached the younger parts of the hyphæ they conjugate with the indigenous nuclei and, on the division of these conjugate pairs, clamp connections are produced.

The work of Lehfeldt on *Typhula erythropus* is thus confirmed. The significance of this confirmation is discussed with reference to recent work on the diploidisation of *Coprinus*.



Mr. C. G. C. CHESTERS and Mr. C. J. HICKMAN.—*Root and stem diseases of the cultivated Viola* (11.25).

The paper deals with the increasingly serious root and stem infections of *Viola* due to fungi belonging to the following genera; *Pythium*, *Ascochyta*, *Mycothecium* and *Rhizoctonia* and describes the field symptoms of the diseases caused. The necessity of recognising the causal organism of certain diseases is emphasised in relation to the control measures to be adopted. Certain morphological characters of the parasitic fungi are described—especially in the case of the species of *Pythium* and *Ascochyta*. The most usual species of *Pythium* isolated from diseased *Viola* plants differs from species of this genus already described—it is tentatively recognised as a new species.

Mr. J. S. L. GILMOUR.—*Whither taxonomy?* (11.50).

With the development of genetics, cytology and ecology, thirty or forty years ago, taxonomists began to realise that, if a system of classification was to reflect accurately the true structure of the plant kingdom and to form an adequate vehicle for further progress, its basis must be widened to include the facts revealed by these new sciences. A number of taxonomic studies accordingly began to appear on these new lines, side by side, of course, with a continuation of the old type of work based solely on morphological and distributional data. To-day these two streams of taxonomic activity have partially separated out into what have been conveniently called the 'alpha' (or old) and 'omega' (or new) taxonomy respectively. What of the future?

It will be generally agreed that, while 'alpha' work is still essential, especially for little-known floras of which only herbarium material is available for study, 'omega' methods can be fruitfully applied to well-known floras of which ample material exists for cultural, genetical and cytological work. The author puts forward the view that these two streams should be much more clearly separated than at present if they are not to interfere with each other to their mutual disadvantage. He does not, of course, advocate non-co-operation, but, rather, full recognition of the different concepts and terminology involved in the two taxonomies, and, if possible, the attainment of a measure of agreement between taxonomists, geneticists, cytologists and ecologists on a common basis for further 'omega' progress.

Mr. A. G. LOWNDES.—*Flagella movement (illustrated by a cinematograph film)* (12.20).

By means of high-speed cinema photomicrography it has been possible to prove the following:

(1) The waves are propagated along the flagellum of *Peranema* from the base to the tip and not in the opposite direction.

(2) The waves are propagated along the flagellum with an increase in velocity and also an increase in amplitude, and hence the flagellum cannot be obtaining the whole of its energy from the cell. In other words the flagellum is not a passive unit mechanically operated by the cell.

This has finally answered a question over which there has been considerable controversy.

(3) Four other species of uniflagellate organisms have been investigated by the same method and the same conclusions are to be drawn.

(4) The distinction between a pulsillum and a tractellum is not really

valid. Impulses pass along the flagellum from the base to the tip and the organism is driven in the opposite direction. If the flagellum were held out in a more or less extended position the organism would be driven backwards, but in each of the organisms studied the flagellum is bent so that the impulses supply a forward component. Hence the organism is driven forward.

#### AFTERNOON.

Mr. G. E. SMITH.—*A developmental study of the epidermis* (2.15).

A number of obscure points in leaf development as a whole having been encountered during a previous investigation, the elucidation of certain of them was attempted.

Some aspects of the developmental history of the epidermis form the subject of the present communication, including :

- (a) The time of appearance of stomatal initials.
- (b) Regular and irregular division of the epidermal cells.
- (c) 'Epidermal mother cells.'
- (d) Development of irregular outline of cells.
- (e) The development of the epidermis of cotyledons and adult leaves of the same plant.
- (f) Some references to the developmental state of the epidermis at the time of food absorption through it in endospermic seeds, at germination.

Dr. M. M. RICHARDSON.—*Structural hybridity and species differentiation in Lilium.*

The concept that most 'Undefined hybrids' are 'Structural hybrids' is shown to be true in *Lilium Martagon album*  $\times$  *L. Hansonii* where a reduced chiasma frequency and occasional failure of pairing of homologous chromosomes are associated with structural change. *Lilium Martagon album*  $\times$  *L. Hansonii* is heterozygous for six inversions whose positions at a particular locus in particular chromosomes have been determined.

The effects of crossing-over in structurally dissimilar bivalents are discussed according to the Neo-Chiasmatype theory of crossing-over. Expected behaviour is considered (a) for all kinds of structural change and their relation to the centromere, (b) for the different kinds of crossing-over in the dislocated segment, (c) the relation of such cross-overs to crossing-over in other parts of the bivalent. It is only by a fully correlated knowledge of the form and separation of bivalents at both the first and second meiotic divisions, and thereby of new chromatid structures, that we can analyse the exact nature and position of the structural change.

Crossing-over occurs distally and proximally to the inversion as well as in it. Double crossing-over in an inversion is also shown to have taken place in another species of *Lilium*.

This investigation gives a method for the analysis of the causes underlying the failure of pairing which characterise species hybrids, and shows the significance of structural change in the formation of species.

Mr. S. RAMANUJAM.—*Chromosome studies in the Oryzæ* (3.5).

The Oryzæ with their primitive and advanced characters have long presented difficulties to taxonomists in regard to their classification and relative position in the family.



A Karyo-systematic study, which has not hitherto been made, was undertaken and results so far available point to the following conclusions :

1. The basic number of chromosomes for the tribe is 5 and not 12 as was supposed by Avdulov.

2. While a certain section, viz. *Zizaniæ*, retained the original basic number, as in two species of *Zizania* ( $2n = 30$ ) and *Lygeum spartum* ( $2n = 40$ ), another section, viz. *Oryzineæ*, which includes Rice, developed a secondary basic number 12 through secondary polyploidy, as in the several species of Rice ( $2n = 24$  and 48) and two species of *Leersia* ( $2n = 48$ ).

3. The monotypic genus *Lygeum*, which has altogether a different habit and distribution, differs from the rest of the tribe in having larger chromosomes.

4. Both allo- and autopolyploidy appear to have played a part in the differentiation of species and genera. While *Lygeum spartum* appears to be an autopolyploid, certain species of *Oryza* are likely to have been derived through allopolyploidy.

Detailed studies, comprising other genera as well, are in hand.

Mr. C. E. FORD.—*Chromosome studies in the Malvaceæ* (3.30).

Chromosome numbers of some thirty species are reported. These support the view that the numbers 5 and 7 are basic for the family. In *Malva* all the species examined are polyploids on a basis of 7, whereas in the closely allied *Lavatera* aneuploid numbers also occur. There is a wide range of haploid numbers in the genus *Hibiscus* such as  $n = 19, 33, 65$  and  $72$ . Diploid and tetraploid races have been found in the two cultivated species, *H. esculentus* and *H. cannabimus*. In *Abutilon* the species fall into two groups, one with 7, and the other with 8 as the basic number.

Chiasma frequencies at metaphase ranging from 1.26 to 1.72 per bivalent were determined in *Abutilon graveolens*, *Anoda cristata*, *Sidalcea oregona* and *Sidalcea candida*. The terminalisation coefficient was approximately equal in the first three species at 0.85, but in *S. candida* it dropped to 0.67.

A connection between one bivalent and the nucleolus is clearly visible at diakinesis in *Sidalcea oregona* and at prophase of mitosis in *Thespesia lampas*.

In all species examined, prochromosomes were present in the resting nuclei of root-tips. They were also observed in tetrad nuclei and in the nuclei of anther wall cells.

Dr. T. SWARBRICK.—*Relationships of scion and rootstock in fruit trees* (3.55).

It has already been established that clonal vegetatively raised rootstocks influence tree size and precocity. Recent experiments have been carried out at Long Ashton whereby trees have been raised which have a common absorbing root system but which have intermediate stem pieces of the three rootstocks MIX, II and XIII. These three rootstocks, when used in the normal manner to provide a complete absorbing root system, produce trees which, as regards vigour, are dwarf, semi-vigorous and vigorous respectively. These experiments show that the effects produced in the scion variety are almost similar in every respect, when an intermediate stem piece of 9 inches long of these three rootstocks, and when the rootstocks are used in the normal manner. Quantitative data are presented in support of the above effect upon tree size and root development. Quantitative effects upon foliage and habit of tree growth are described. The three intermediate stem pieces of MIX, II and XIII show marked differences



in their radical development and the union they make with the rootstock and the scion. The possible rôle of the graft union and the physiology growth cycles in the stem pieces is discussed in relation to the so-called rootstock influences.

SEMI-POPULAR LECTURE by Prof. E. J. SALISBURY, F.R.S., on *The living garden* (5.0).

### Saturday, September 12.

Excursion to Southport sand dunes.

### Sunday, September 13.

Excursion to Windermere, Wray Castle.

### Monday, September 14.

Prof. J. H. PRIESTLEY and Miss L. I. SCOTT (10.0). (See *Department of Forestry*, below.)

Prof. W. STILES, F.R.S., and Dr. W. LEACH.—*The relationship between respiration intensity and oxygen concentration* (10.30).

Prof. R. RUGGLES GATES, F.R.S.—*The genetic survey as a method of evolutionary study* (11.0).

Hitherto very few, if any, intensive genetic studies have been made of plants collected wild over a particular area. Ecotypes of various species have been investigated in this way, and in a few genera, such as *Crepis*, numbers of species have been brought together for a comparative genetic study. The aim of the present work is, by collecting the wild seeds of a genus at short intervals over a given area, to make an intensive genetic survey of all the existing forms, their relationships and distribution. This was done with *Oenothera* in eastern Canada, one hundred seed collections being made in 1932 and about sixty more in 1935. The resulting cultures show a surprising range of variation, including many new species and varieties. By this method, which has been intensively followed for the first time, much light is thrown upon the variations, geographic distribution and phylogeny of the genus *Oenothera*. The fact that seeds from any wild plant generally breed true to type, often showing minute differences from plants of a neighbouring area, results partly from the presence of a ring of fourteen chromosomes in all these forms.

Dr. N. L. PENSTON.—*Potassium in leaves* (11.30).

The changes during the day of dry weight, ash weight and potassium content in leaves of potato and maize, and the osmotic pressure changes of the sap in potato leaves, are shown in tables and graphs, and the results discussed in relation to accumulation of solutes in the metabolising leaf.

Mr. J. GILLESPIE.—*The influence of certain chemical elements upon the development of chlorophyll in plants* (12.0).

This contribution records preliminary investigations of the relationships and interrelationships of chemical elements in the formation of chlorophyll. Iron, zinc and manganese in culture solutions have so far been employed.

It is confirmed that the different salts of iron have different abilities to catalyse chlorophyll formation, but an iron salt which is most efficient for one species may not be the most efficient catalyst in another species. The variations in chlorophyll content in different species, brought about by different iron salts, are correlated with variations in dry weight.

Zinc in small quantities helps to increase the amount of chlorophyll developed, but beyond certain concentrations of zinc salt the amount of chlorophyll decreases. High concentrations of zinc lead to orange-spotted leaves or chlorosis.

In concentrations of zinc salt which tend to induce chlorosis, the addition of minute traces of manganese restores normal green coloration.

Plants grown in shade or darkness and subjected to the action of a zinc salt recover from light-chlorosis more slowly than controls.

#### AFTERNOON.

MR. H. G. CHIPPINDALE.—*The vitality of grass seedlings* (2.15).

A study of the behaviour of grass seedlings subject to interspecific competition has led to an inquiry into their toleration of conditions inhibiting growth. Their vitality has been found to be remarkable.

A large proportion of seedlings survive desiccation for several days at laboratory temperature, new growth being initiated in the shoot primordia. The property is possessed in varying degree by different species, and may also be affected by the previous history of the seedlings.

The longevity of seedlings in complete darkness is dependent upon temperature, but exceeds what would be expected from the food reserves in the caryopses. At an average temperature of about 7° C., seedlings are alive after several months without light, and on its admission are capable of normal growth. Seeds germinating below the soil in autumn may not show visible seedlings at the surface until the following spring.

Both the intensity and quantity of light requisite for the growth of grass seedlings are extremely small; when below the minimum, survival of the seedlings is protracted, and it is possibly dependent upon mineral nutrition.

DR. WINIFRED E. BRENCHLEY.—*The varying response of weed species to competition* (2.40).

The competition of weeds with crops plays an important part in economics, but the factors influencing the competition are not fully understood. Probably in some cases the apparent association of certain species with particular types of soil is in reality determined by the relative competition.

When arable land is fallowed, the succeeding wheat crop tends to be very heavy on account of the accumulated fertility, but in spite of this heavy crop such weeds as *Alopecurus agrestis* may show a big increase, although under normal cropping conditions wheat and *Alopecurus* come into active competition. Weed species may be divided into three groups according to their behaviour after fallowing:

(1) Species which fail to reassert themselves in the face of crop competition. *Papaver rhæas* came into this group at Rothamsted, in spite of the large number of seeds which survived fallowing.

(2) Species which withstand the competition of the crop and replenish their stocks of seed in the soil.

(3) Species which respond variably after different periods of fallowing.

Extreme cases of competition are exemplified by Broadbalk and Gees-croft 'Wildernesses.' In the former an uncut wheat field has reverted to



a dense oak-hazel woodland, whereas in the latter *Aira cæspitosa* dominates, and brambles and saplings are very gradually becoming established.

Response to competition is also affected by the ability of such plants as *Capsella bursa-pastoris* to mature seed rapidly at various seasons of the year.

Miss A. C. HALKET.—*The periodic movements of the flowers of some nyctanthous plants* (3.5).

The results of a study of the flowers of some nyctanthous plants are presented. The flowers studied were *Melandryum album*, *Melandryum noctiflorum*, various species of *Silene* (*S. Vallesia*, *S. nutans*, *S. ciliata*, *S. tartarica*, *S. Zawadski*, *S. maritima*), *Schizopetalon Walkeri* and *Matthiola bicornis*.

The flowers of different species open for a varying number of evenings, many of them opening about six times. The hours of opening and closing vary with the weather; in most species the buds expand later in the evening than the older flowers. On wet days the flowers remain open.

The 'closing' of the flowers is due to the inrolling of their petals. The petals close gradually as they lose water and open as they absorb it. The percentage of water is greater in open than in closed petals.

Comparison of the areas of petals when closed and open shows that they change considerably in size. The changes in area are due to the contraction or expansion of the cells as water is lost or gained.

The petals increase in size as they grow older; their movements, however, are not growth movements but depend on their water-content, and are related to the anatomical structure of the petals and the nature of their cell-walls.

Dr. G. TAYLOR.—*The British Museum expedition to the mountains of East Africa* (3.30).

The expedition visited four groups of mountains in East Africa and was organised to make a comparative study of the flora and insect fauna at higher altitudes, to obtain specimens and to ascertain whether any comparable peculiarities existed between the plants and insects. It will be some years before the collections are fully worked out, and at present it is possible only to describe the characteristic vegetation of these regions and the elements represented in this unique flora.

Perhaps the most striking feature is the altitudinal zonation of the vegetation and the manner in which it tends to repeat itself on the different mountain groups. In the lowest zone the plants are characteristic of the African plains, but the type of vegetation changes through tropical forest and dense bamboo forest until one meets on the one hand plants strongly reminiscent of Europe and, on the other hand, grotesque forms which are characteristic only of these African mountains. The vegetational zones may be quite sharply defined, but, as a rule, they overlap for a considerable depth and their altitudinal range may vary on the different mountains and even on each side of the same mountain. Occasionally, but very rarely, the bamboo zone may be absent.

It is in the highest zone that specialisation of the species has proceeded furthest, and the same genus is usually represented by different species on each mountain top and frequently, but particularly in the arborescent *Senecios*, these species are local endemics. Each mountain can be regarded as an island arising from a sea of tropical vegetation, each island having its own characteristic plants, though all are of the same general type.



Apart from the typically African elements, the most interesting feature of the alpine zone is the presence of so many representatives of temperate genera, as, for instance, species of *Ranunculus*, *Arabis*, *Subularia*, *Cardamine*, *Limosella*, *Sibthorpia*, *Luzula*, *Anthoxanthum*, *Deschampsia* and *Koeleria*; the species may, indeed, be identical with those found in this country. It appears probable that these are relics of a former more extensive temperate flora, and their isolated presence in the alpine zone of the African mountains can probably best be interpreted from a study of the climatic history of these regions.

## Tuesday, September 15.

Dr. M. ROSENBERG.—*Algal cultures* (10.30).

A survey of methods for algal cultures is given. The various factors, such as chemicals, light and temperature, are discussed and their importance demonstrated.

The chief problems which have been approached with the help of culture methods are outlined; and examples are given chiefly of results concerned with ecological and morphological investigations. In several cases it has been possible to correlate changes in external conditions with corresponding morphological or physiological changes (division rate).

Culture methods, especially among the Desmids, open a wide field for investigations, owing to the variations which occur in this group.

In the genus *Xanthidium*, for instance, it has been possible to show that two morphologically distinct types—so far considered as two species—really are varieties of one species only, brought about by changes in the external conditions.

Mention of results by various authors working on these lines is also made.

Miss M. REESE.—*A study of the microflora of two Cardiganshire rivers and the effect of local lead mines on their algal population* (11.0).

A short history of the lead mines followed by an account of the pollution they cause.

A description of the physical features of the rivers Rheidol and Melindwr, and an account of the collection of the microflora, its periodicity, and the relation of the plants to floods.

Prof. J. DOYLE.—*Development in Sequoia* (11.30).

Fertilisation and pro-embryo formation are described for *Sequoia gigantea*. The gametophytes resemble those of *Sequoia sempervirens* closely, but the pro-embryo, although showing variations in the later stages, is essentially Cupressinean in type.

Wall formation at the first post-fertilisation division is verified for *Sequoia sempervirens*. Subsequent pro-embryo development is clarified. Among other points of interest, it does not fill the archegonium when young.

Prof. T. M. HARRIS.—*The fossil horsetails (Equisetites)* (12.0).

Some Mesozoic horsetails are briefly described; most of their features being in obvious agreement with those of *Equisetum*. Their vascular

anatomy, however, has appeared to be different: in most specimens the vascular bundles are not preserved, but the markings at the node suggested that the bundles were twice as numerous as the leaves instead of being equally numerous. Preparations of *Equisetum* have been made by bacterial rotting followed by compression which show features at the node agreeing with those of the fossils, thus suggesting the explanation of their peculiarities and removing what seemed an important point of disagreement. It is further suggested that in the Equisetales the water-conducting system is double, consisting of a carinal canal supplemented by more or less developed metaxylem. In the Calamites the xylem is well developed and in the compressed fossil forms a ridge, while in *Equisetum* it is a vestige playing a small part in conduction, and when rotted and crushed experimentally or when fossilised becoming unrecognisable. This would account for the 'pith cast' of Equisetites being smooth, that of a Calamite being striated.

Dr. T. JOHNSON.—*Dulichium spathaceum* Pers. from Corker Hill, Glasgow (12.30).

As a possible help in dating a human skull of uncertain age unearthed at Corker Hill, Glasgow, I undertook the separation and examination of the fruits, seeds and other plant material present in the turf in which the skull was embedded. I was so fortunate as to enlist the aid of Mrs. Clement Reid, who found, in the collection made, the fruit of *Dulichium spathaceum* Pers., a sedge hitherto unknown from the British Isles but recorded from the 'Interglacial' beds of Denmark and North Germany, as well as from Renver in 1908 by Mr. and Mrs. Clement Reid. This sedge, owing to a change from the oceanic to the continental type of climate, disappeared from Europe but still lives on the Atlantic side of North America. *Gladium jamaicense* Crantz (*G. mariscus* Br.) and *Salix aurita* L. with Interglacial records were also found. The cold, wet habitat is further indicated by the subarctic *Sphagnum Austini* Sull., and by (a tubular artifact of) oak-wood with rings, half the normal width. *Liastrea Thelypteris* Bory, the marsh fern, occurred. *Pteris aquilina* was plentiful (and may have provided bedding and thatching for dwellings, supported by the roughly pointed birch stakes found).

Some thirty different species of seeds of no special interest were isolated. Charcoal and vivianite were common. Sedge and skull are not necessarily contemporaneous.

#### AFTERNOON.

EXHIBITS :—

Prof. Dame HELEN GWYNNE-VAUGHAN, G.B.E., and Mrs. Q. E. BROADHEAD.—*The development of the long perithecial neck in Ceratostomella fimbriata.*

Prof. B. NĚMEC.—*Gold and other rare elements in plants.*

Dr. C. E. FOISTER, Mr. I. W. TERVET, and Mrs. N. L. ALCOCK, O.B.E.—*Rot in stored potatoes.*

Mr. H. D. GORDON.—*Mycorrhiza in Rhododendrons.*

In nature the roots of rhododendrons regularly contain an endophytic fungus, similar in appearance to the endophytes recorded in *Calluna*,

*Vaccinium* and the majority of the Ericacæ. The infection appears to be confined to the roots, and has not been observed in stem, leaf, fruit or seed.

The endophyte is not seed-borne, and seedlings are normally infected from the soil several weeks after germination.

Seeds have been germinated, and the resulting seedlings grown, in pure culture, without the presence of the endophyte or of any other micro-organisms. Such seedlings are capable of development, and can produce a copious root system.

Thus the relation of the higher plant to the endophyte is not an obligate one.

Mr. S. I. RAMANUJAM.—*Chromosomes in the Oryzææ*.

Dr. T. SWARBRICK.—*Relationships of scion and rootstock in fruit trees*.

Mr. G. E. SMITH.—*A developmental study of the epidermis*.

Prof. T. HARRIS.—*Fossil horsetails*.

Dr. T. JOHNSON.—*Dulichium spathaceum Pers.*

Dr. L. DUDLEY STAMP.—*Land utilisation maps*.

Mr. F. T. BROOKS, F.R.S.—*Allomyces javanicus* Kniep.

Miss E. M. DEBENHAM.—*Some applications of the ammoniacal acid fuchsin technique*.

Mr. J. W. G. LUND.—*Mud-inhabiting algæ*.

Dr. M. POCKOCK.—*Stages in the life cycle of Volvox and other South African algæ*.

## DEPARTMENT OF FORESTRY (K\*).

Thursday, September 10.

Mr. D. W. YOUNG.—*The New Forest* (11.0).

Mr. A. P. LONG.—*Hill planting* (11.30).

Mr. J. A. B. MACDONALD.—*The afforestation of difficult sites* (12.0).

To the ardent forester there are problems or difficulties connected with the afforestation of every conceivable 'site' or type of ground. Difficulties may indeed result from the very fertility of the soil itself—for instance, weed growth may be so encouraged that the planted trees are in danger of becoming smothered. The paper, however, deals with sites in which the difficulty arises from the poverty or unfavourable physical conditions of the surface layers; attention is confined to hill sites. In such circumstances climatic perhaps more than edaphic factors are primarily responsible



for the bad conditions. Naturally where both rock and weather are unfavourable the worst types of ground occur—here a peat layer almost invariably exists. Roughly these peat-clad sites may be divided into three classes: basins, slopes and knolls. Afforestation experiments have been proceeding on such sites for the last ten to fifteen years, and the interim results or tendencies are already of considerable interest. There have also been many experiments laid down on two other difficult types: (1) Calluna-clad moorlands on which a dry raw-humus takes the place of the peat layer, and (2) dry Calluna-clad, often morainic slopes, where the raw-humus layer is scanty or absent. On the poorer peat sites the difficulty is to get any tree species to become established; on the dry heather ground the problem is rather the establishment of a more valuable crop than Scots pine, which it is known would grow more or less vigorously.

Dr. A. B. STEWART.—*Some soil problems in forest nurseries* (12.20).

To illustrate the type of information which may be obtained from a soil examination reference may be made to some results which have been obtained for different nursery soils.

It was found that Scots pine seedlings from soil A showed marked 'browning,' whilst normal healthy plants were obtained in soil B. Specimen plants were taken for analyses from these two soils, and it was found that the healthy plants from soil B had a lime content in their ash of approximately 20 per cent. CaO, a figure which agrees well with that given by Manshard<sup>1</sup> as typical of normal seedlings. The lime content of the ash of the affected plants from soil A was approximately 40 per cent. CaO. Soil A was found to be much richer in lime and lower in both phosphoric acid and potash than soil B. It appears likely therefore that the poor results obtained in soil A are to be associated to some extent at least with the unfavourable nutrient balance in the soil, where the ratio of calcium to other nutrients, particularly potassium, is very high. That the high calcium content in itself is not likely to have been wholly responsible for the 'browning' of the seedlings is borne out by the observation that normal healthy plants can be grown in soil C. This has also a very high lime content, but is very much richer in readily soluble phosphoric acid and potash and has a more balanced nutrient content than soil A.

Experiments are at present being conducted in conjunction with the Forestry Commission (Scotland) in order to obtain more accurate information on the amounts of lime, phosphoric acid, potash and other nutrients which should be added in order to obtain in the soil the most suitable nutrient balance.

## Friday, September 11.

DISCUSSION ON *The utilisation of home-grown timber* (10.0).

Rt. Hon. Lord CLINTON.—*The position of private estates in the production of timber.*

Mr. F. G. O. PEARSON.—*The existing outlets for home-grown timber.*

If afforestation is to pay, the produce of plantations must be utilised at every stage of growth.

<sup>1</sup> *Tharandter Forst. Jahrbuch*, 84, 2. 1933.

The main classes of produce are :

(1) Poles  $1\frac{1}{2}$  to 5 in. at the butt.

The market for these must be found locally, chiefly in rustic work, fencing stakes, hurdles and small turnery.

(2) Poles 5 to 8 in. at butt.

These are suitable for pit-props, fender poles, telephone poles and stay-props, and turnery.

(3) Poles over 8 in. diameter but not mature timber.

Can be used for large pit-props, contractors' piles, and fencing material, or sold to merchants for conversion to general uses.

(4) Mature timber.

Is sold to timber merchants, either standing, by estimated measure and an agreed price for the whole wood, or by the cubic foot when felled.

(5) Coppice.

This is sold by the acre, chestnut for fencing, hazel, ash and birch for pea and bean sticks, etc.

(6) Lop and top.

These are trimmings from felled trees, and sold either by the cord or by the ton, chiefly for firewood.

There is a market for all these classes, which will improve as supplies increase and marketing becomes more orderly. Local Government authorities, railways and other large corporations could help by purchasing home-grown timber more often.

Mr. JOHN T. SMITH.—*The utilisation of certain British softwoods.*

Substantial increase in knowledge of forestry in Great Britain and striking decline in consumption of home timber.

Information regarding proportion of home timber used in this country.

References to the literature now available on the subject.

Attenuated condition of British woodlands.

Possibility of using the existing timber trade organisation of the United Kingdom for marketing home timber. Parallel to be found in North European countries.

Utilisation of individual species, with notes upon :

1. Scots pine.
2. Norway and Sitka spruce.
3. Larch.
4. Douglas fir.
5. Others.

Bibliography.

Mr. J. W. G. AGATE.—*The uses and working qualities of British hardwoods.*

Mr. G. H. DONALD.—*The effects of pruning on the quality of timber.*

An account of the investigation in progress at the Forest Products Research Laboratory, Princes Risborough, on the practical and economic effects of pruning forest trees. Deals briefly with the reason why artificial pruning is believed necessary, and then describes the examination of actual

pruned material with the object of finding out what happens after pruning—how long healing takes and what is the nature of the occluded wound.

The assessment of the improved quality, and therefore greater value, of timber as a result of pruning cannot very well be carried out on actual pruned material, since trees pruned under suitable conditions and sufficiently long ago to affect the timber have not been found to be available. The paper describes the method of grading the sawn timber from ordinary unpruned logs, and then, by carrying out a hypothetical pruning in retrospect, comparing the present value of the timber with the value it would have had if a given pruning had been carried out.

### Saturday, September 12.

Excursion to Lake District (Belle Isle Estate, etc.).

### Sunday, September 13.

Excursion to Thirlmere.

### Monday, September 14.

Prof. J. H. PRIESTLEY and Miss L. I. SCOTT.—*A comparison of ring-porous and diffuse-porous hardwoods* (10.0).

Recent work has emphasised the significance of the differences between these two types of hardwood tree. These differences are analysed; they are shown in the manner of extension growth and radial growth, and in differentiation and structure of the wood. They may also have significance in connection with the function of the wood.

Mr. RAY BOURNE.—*The beechwood associations of southern England* (10.30).

The beech is the principal climax dominant of the hilly country throughout southern England irrespective of geological formation and soil. The rate of growth and dimensions attained vary with the climate and the soil. The associated species in the tree and ground layers are determined with one or two exceptions by soil rather than by climate. Three principal associations can be recognised:

- (1) The beech-oak-birch association on the acid sands and gravels.
- (2) The beech-oak-ash association on the neutral loams and clays.
- (3) The beech-ash-yew association on the calcareous chalk and lime stone brash soils.

Each association is divisible into types of distinct physiognomy and productivity. The recognition of the types which occur on an estate is an essential preliminary to the successful solution of the problems of silviculture and management.

Mr. H. A. HYDE.—*The position of the beech in South Wales* (11.5).

The present investigation is an attempt to determine the status of beech (*Fagus sylvatica*) in certain woods in Glamorganshire, South Wales. The woods concerned are situated to the north of Cardiff on hills (100–900 ft. alt.) running W.S.W.–E.N.E. for a distance of approximately seven miles at an



average distance of six miles from the middle of the city. The rock underlying the woods for the most part is Carboniferous Limestone, including Lower Limestone Shales, but some are situated on Old Red Sandstone and one on Pennant Grits (Carboniferous). The soils have not been fully investigated. There are no records of the planting of these woods, but they have decreased in area considerably during living memory due to felling. Regeneration has been observed in one wood at least, and seedlings are not uncommon throughout.

The investigation of the floristic and ecologic composition of the woods is as yet only in a preliminary stage.

Mr. HENRY P. HUTCHINSON.—*The effects of dormant buds and roots on the wood of Salix cerulea—the cricket bat willow* (11.20).

The paper traces the behaviour of the primary buds and initial roots present in the current year's shoot through the later stages of growth of the tree, and describes the effects produced on the grain of the underlying timber.

Mr. E. H. B. BOULTON.—*Timber and its substitutes* (11.40).

Mr. H. D. GORDON.—*Mycorrhiza in rhododendrons* (12.10).

Mr. B. POLLARD-URQUHART.—*Working plans for the private estate* (12.40).

## SECTION L.—EDUCATIONAL SCIENCE.

Thursday, September 10.

DISCUSSION ON *Cultural and social values of science* (10.0).

Sir RICHARD GREGORY, Bt., F.R.S.

Culture has the same meaning as the humanism of polite scholarship or classical learning: and whatever subjects are defined as humanistic, they must all be understood as being concerned with the welfare of man.

The influence of science upon material progress is recognised much more commonly than that of its effect upon the human mind. It is difficult now to realise the liberation of life and intellect brought about by the works of Copernicus, Galileo, Vesalius and other pioneers of experimental philosophy. Their discoveries, and Newton's law of gravitation, which accounted not only for the movements of the planets but also for the alarming appearance of comets, involved a revolution in conceptions of the universe and man's terrestrial dwelling-place. Intellectual expansion, and a sense of justice, resulted from the knowledge of the existence and permanence of Law in Nature. They profoundly influenced human thought and resulted in social changes which had great civilising effects.

Three centuries later, Darwin placed man himself in a new relationship to the rest of living creatures, and the principle of evolution established by him applies not only to the past but also to the present and future. Science,

and its effect upon invention and mechanisation, have created a new environment which can be shaped to satisfy man's intellectual as well as his material needs. The most important problem to-day is that of finding a means to lessen the gap between scientific advance and ethical and social development.

Prof. L. HOGBEN (10.30).

The scientific knowledge gained during the past century has produced a surfeit of commodities which the existing economy of distribution has failed to make available for human welfare. In part this situation is the nemesis of a personnel of government educated in a humanism which has no roots in scientific knowledge. The pivotal issues of modern education are the production of political leaders who realise the new potential of human welfare and the training of citizens who will choose leaders with the necessary knowledge to deal constructively with the impact of science on social institutions. The teaching of science in the schools and universities has been largely moulded by the demand for specialist knowledge by industry, medicine and new social services. Compulsory courses in science designed to meet this demand can make little contribution to a new humanism with its roots in a scientific attitude to external nature and human destiny. The attempt to design courses of general science suitable for those who will not become specialists has largely failed through lack of a clearly defined and sufficiently comprehensive social objective. To fulfil the social objective stated above it is not sufficient to show how science is used in the everyday life of contemporary civilisation. It is equally important to exhibit the growth of civilisation in its relation to advancing scientific knowledge and to unfold possibilities for the further use of scientific knowledge which we have not fully applied to social well-being. To accomplish this the training of the science teacher must be broadened to include a thorough knowledge of the history of science, taught in close relation to the social needs and circumstances in which scientific progress has been made and the uses to which it has been put. This will not be achieved by introducing courses in the history of sciences treated as a succession of discoveries by specially gifted individuals whose relation to their social environment is ignored. It will necessarily entail a reorientation of the contents of the curriculum. For instance, the dependence of calendrical practice and navigation on the progress of astronomy from the dawn of civilisation to the age of Newton receives little recognition either in current teaching of history or of natural science in the Universities, where astronomy is rarely taught except as an appendix to higher mathematics. As immediate measures to facilitate the design of science teaching adapted to the requirements of intelligent citizenship, the steps which might be made include a much greater degree of encouragement of cosmography in the new departments of geography in the Universities, provision for specialist teaching in the social relations of science and technology in departments of history and compulsory degree courses in the history of science and its uses for students of natural science.

Mr. S. R. HUMBY (11.0).

What are the ideas which the teaching of science in schools should leave in the minds of the citizens of the future, and how can these ideas best be presented?

Emphasis should be laid on the increasing powers which men have gained over substances and over energy. These have been obtained from pioneer



work by investigators who have sought knowledge and have found that, through that knowledge, nature can be controlled but not coerced.

An understanding of the particular methods by which scientific knowledge has been gained should become part of the mental equipment of the ordinary person. The reactions between scientific progress and the structure of society should be pointed out.

The critical powers should be trained so that the young citizen will be apt to suspect the abundant panaceas of the self-interested and the thoughtless.

Mr. S. V. BROWN (11.20).

What is the cultural and social value of science as at present taught in a day secondary school?

In the main, secondary schools cater for three types of pupils :

- (a) Those who eventually become science specialists.
- (b) Those who become specialists in non-science subjects and who will probably receive no instruction in science after the age of 18.
- (c) Those who leave school at 16 plus and whose formal education may then be regarded as finished.

Of these, class (c) comprises over 90 per cent.

So far, the secondary school curriculum has been almost entirely based on the needs and requirements of class (a), the future science specialists, and it is very doubtful whether it has much cultural or social value even for them, for we are constantly being reminded that our science specialists are narrow-minded and lacking in general culture.

As for the rest, there seems no doubt that the course is of negligible benefit in after life as far as the cultural side is concerned.

The remedy would appear to be to institute a course of general science for all pupils up to the age of 16 plus, followed by a modified specialisation up to 18 plus. The writer favours no specialisation at all during a pupil's secondary school life, believing that the place for specialisation is the University.

The crux of the whole problem lies in the framing of the general science course. Previous attempts at framing such a course have resulted in producing something which was 'general' but was not 'science.' The natural interest, for which science has its growing point, is 'life.' Therefore biology is the regulative science: to it physics and chemistry are, by the normal run of human interest, subordinate and should take second place. They are, when studied, more of a specialised study than is the study of life, being themselves the means and conditions of life: their other and independent interest is a more recondite study and is not 'general science.'

General science does not consist of the facts of chemistry, physics and biology studied piecemeal and in watertight compartments, but is to be regarded as a unified and living whole, the theme of which is 'life.' It is the interpretation of the world in which we live and includes not only an understanding of the fundamental principles but also of the attitude and method of science generally.

Sir DANIEL HALL, K.C.B., F.R.S. (11.45).

The true aim of science is the enrichment of life. It is commonplace to enumerate the gifts of science—communications, light and heat, textiles, food, the saving of manual toil. On the cultural side the gains are no less—



travel, photography, the gramophone and wireless bring history, art, music and awareness to the ordinary man.

None the less science is beginning to take on the aspect of an enemy, frustrating the enjoyment of all the advantages it confers. The acceleration of production has led to over-production and under-employment; the new technique of war is a menace to civilisation. Science means power; to whom shall it be entrusted and to what ends shall it be used? It supplies the greatest of all temptations to the power-mongers. Robot nations are being created by the control of the press and wireless, by the closing of frontiers, by propaganda and education itself.

Is science to be for the few or for all? The hope only lies in the universal diffusion of an education based on science, whereby may be built up a habit of mind that will act on reason rather than on mass emotion. Science alone can destroy the great illusion that one belongs to a chosen race, and teach the people that men and women, however diverse individually, are collectively very much alike.

But to education must be added the organisation of scientific opinion. Men of science must leave their ivory tower and join in the common fight for freedom.

#### AFTERNOON.

Visit to Schools.

### Friday, September 11.

PRESIDENTIAL ADDRESS by Sir RICHARD LIVINGSTONE on *The future in education* (10.0).

DISCUSSION on *The pre-school child* (11.0).

Mrs. M. WINTRINGHAM.—*Emergency Open-Air Nurseries in the Distressed Areas.*

The growing recognition of the importance of pre-school life has led of recent years to greatly increased interest in the subject of nursery schools all over the country. In the distressed areas in particular, where life is handicapped in every way from start to finish, the importance of caring for the very young is of special moment. Hence the Emergency Open-Air Nursery School movement under the auspices of the 'Save the Children Fund,' which is not only an effort to save the children from the worst effects of the depression, but also one of the most hopeful pieces of community work that has been initiated in our time. The account of the rise and growth of nursery schools in the special areas, their organisation and their results, will form a valuable chapter in the sociological history of the present generation.

Miss ISHBEL MACDONALD (11.20).

Dr. SUSAN ISAACS.—*Certain aspects of mental development in the pre-school child* (11.40).

(a) The two-year-old child is still very dependent upon a close personal relation with an adult woman. He seeks attention, protection and love from

her, and is not yet ready to share her services with other children to more than a limited extent. If he is plunged into a large group of children of the same age, with only one or two adult guardians, he suffers both great anxiety arising from his natural attitude of rivalry to other children, and emotional starvation, since the adult helper cannot under such conditions give adequate attention to each child.

(b) Social development during the nursery school years requires that the children should have opportunity to form groups spontaneously for their own purposes in play. These spontaneously formed groups are small and evanescent, but they provide the experience through which genuine social feelings can grow. When an adult imposes group activities on a larger number of children, whether this arises from practical necessity or from the desire to encourage social feelings, this has not the same psychological value. It is forced and artificial, and often cuts across the natural impulses of the young child to play intensively with one or two other children, or to cling closely to the grown-up.

Moreover, it is only in small spontaneously formed groups that the child can speak freely and naturally about his activities. Such natural talk with the grown-up and with other children arising out of his play is the best means of training in language in the nursery school years. More formal occasions provided by artificially arranged group activities have not the same emotional and intellectual value.

(c) Studies of the growth of voluntary attention in young children have shown that the young child needs long periods of free play in which he can learn to follow out his own aims to the end, not interrupted by a rigid general routine. It is, however, only possible to give each child plenty of opportunity for developing sustained attention if the nursery school is adequately supplied with trained workers.

The more we know, therefore, of the psychological conditions which favour the development of social feelings and intellectual effort in the young child, the clearer becomes the need for generous staffing with trained helpers in the nursery school or nursery class.

Miss E. STEVINSON (12.0).

The planning of the nursery school to meet the needs of the pre-school child.

The division of the nursery school day into periods for routine and periods for free activity.

The planning of the free play period, with some account of play material.

The importance of a careful lay-out of the school buildings and the necessity for a specialised training for nursery school teachers.

Miss I. JONES.—*Nursery education in Lancashire : some problems* (12.20).

Scope of paper—to review briefly the general position with regard to nursery education in Lancashire, with special reference to some aspects of the problem as it occurs outside the more congested areas, as for example in :

- (1) A straggling township served by widely separated infants' schools.
- (2) A semi-rural district served by a school with full age-range.
- (3) A small industrial centre served by a two-teacher junior and infants' school.

The problem of providing the essentials of nurture for all children in these varying circumstances. The place and function of the nursery class. Further developments as planned and envisaged.

#### AFTERNOON.

Visit to Stonyhurst College, by road.

### Monday, September 14.

DISCUSSION ON *Part-time continued education* (10.0).

Mr. J. L. PATON.

The weak point of our educational system is the period of adolescence. We build up slowly from below. We let down from above. But there it is—a hiatus, and the hiatus occurs just at the age when the guiding hand of the State is most needed. There is, after the age of fourteen, a tragic loss and not only of intellectual attainment, but, what is worse, of moral quality. This set-back in mind and character is more crucial because of unemployment. The aim of the Fisher Act was to save this waste. 'Can the age of adolescence be brought out of the purview of economic exploitation into that of the social conscience?' asked the Lewis Committee. The Fisher Act was an attempt to do this very thing. It has never been tried out except at Rugby. There it has been a demonstrable success. Why are we not following up this success on a national scale? The raising of the leaving age does not meet the real crying need of our time.

Mr. P. I. KITCHEN (10.30).

*The present system.*—Variety and magnitude in relation to young population : employment of juveniles.

*Changing conditions.*—Widening outlook of continued education reflecting State's expanding social responsibilities.

Need for information on young people in early years of employment.

*Ultimate aim.*—To what extent can education before employment reduce need for education during employment? Limitation of voluntary system. The case for compulsory attendance, and its difficulties.

Sir KENNETH LEE (11.0).

The day continuation school form of part-time continued education, i.e. two half-days per week during working hours, from fourteen to eighteen.

Its advantages over raising the age to fifteen : to the employer, the adolescent and the State.

*The employer.*—Difficulties in works organisation : contact with employees—promotion.

*The employed adolescent.*—Learning and working alternated : oversight and care of growth and health : results in home life.

*The State.*—Dependence upon education, citizenship and more intelligent operatives in industry for rapidly changing processes and machines : no maintenance grants necessary.

The need in modern industry for intelligence and adaptability in the operatives.



The results of the day continuation school and of the elementary school compared at thirty years of age.

The influence of the day continuation school over the functional changes at fifteen to sixteen and its importance for citizenship.

The problem : not education of the child but education of the adolescent.

The merging of interests in the adolescent—education, home, employment and citizenship.

Dr. J. P. McHUTCHISON.—*Courses of instruction for unemployed juveniles* (11.20).

These courses conducted by education authorities, as required by Part VI of the Unemployment Insurance Act, 1935, have as their main purpose the prevention of the demoralisation which would otherwise threaten the welfare of unemployed boys and girls during adolescent years. With some experience of such part-time education on a voluntary basis, the writer welcomed the statutory extension of the work and the fuller opportunity of providing a training more purposeful than ordinary schooling and more related to the needs, moral, social and physical, of the young people in actual life.

Taking as their objective the all-round fitness of the boy or girl, the Junior Instruction Centres have already developed an educational viewpoint of their own and, evoking the loyalty and wholehearted co-operation of the juveniles themselves, have become hives of industrious effort, physical fitness and pleasant comradeship, thus providing a training in true manliness and womanliness and creating worthy young citizens.

Mr. W. B. HENDERSON (11.40).

(1) Explain briefly how from being an opponent of, I became a convert to, part-time continued education.

(2) Why I think education and labour going on side by side is a good thing.

(3) A short account of the experiment conducted by Messrs. C. & J. Clark, Ltd., Street.

(4) The attitude towards the experiment of (a) the boys and girls; (b) the parents; (c) the directors; (d) the foremen; (e) the trade union.

Mr. A. ABBOTT (12.0).

A complete vocational training includes two essential elements—practical experience and theoretical instruction. Both may be provided, as is usual on the Continent, in the technical school itself. In England, the ordinary method is for business to give the practical training and schools the theoretical instruction. This involves close co-operation between the firms and the schools. The school is doing its part by providing 'grouped courses of instruction' in its evening classes: some firms have organised the practical training of their learners, but many more should do so.

Students in evening technical schools are not working merely for the satisfaction of their own ambitions. They are contributing to the welfare of both their industry and the nation, and to require them to devote nearly all their leisure during half the year to study throws on them too great a share of the burden of increasing our industrial and commercial efficiency. It is desirable, in spite of the trouble and expense it involves for their

employers, that promising recruits should be allowed one or two half-days each week during working hours in order to attend technical classes. The existing technical school buildings in England could without extension accommodate about 150,000 additional students, each attending on two half-days a week.

#### AFTERNOON.

Visit to Rossall School, by road.

### Tuesday, September 15.

JOINT DISCUSSION with Section M (Agriculture) on *Education for rural life* (Section L Room) (10.0).

Sir JOHN RUSSELL, O.B.E., F.R.S.—*Education for rural life*.

It has long been recognised that education for rural life must proceed on very different lines from education as developed in the town schools. The country child has a background of experience that the town child lacks, and he lives in surroundings rich in material of high educational value. The difficulty hitherto has been to find the teachers who could adequately exploit these natural advantages. Fortunately enterprising rural teachers have developed a good educational technique: first Nature Study, then Local Surveys and the School Garden, and now comes the reorganisation of rural schools: the provision of Rural Senior Schools to which scholars are transported daily as soon as they are eleven years of age. These schools are at present free agents and have not yet tied themselves either to textbooks or to examinations, and it is to be hoped they will retain their freedom. Their fundamental task is to utilise the local surroundings as the basis of the education, and this demands a far greater degree of flexibility than is possible where the examination schedule rules the courses.

The purposes of the work are:

(1) To train the child's intelligence and give him a sound basis of knowledge of the ordinary things of the countryside.

(2) To give him some elements of culture so that he may use well the considerable amount of leisure he will have when he starts work.

The course should help the child if he elects to follow a country calling, but it is not its purpose to anchor the child to the land either as farm worker or in any other capacity.

The necessary appliances are:

(1) *Adequate ground around the school.* Suffolk already provides 1-2 acres and it is hoped that larger areas will be available. This should give a garden—which should be laid out on decorative lines—a playing field, and a School Estate that can be run properly. All this forms the basis of the work.

(2) *Provision for a local survey.*—The necessary flexibility can be attained only if the teachers are in touch with living sources of information that can help them in the numerous problems that arise. B.B.C. talks, and summer refresher courses, can do something, but some definite linking with the Colleges and Experiment Stations, such as the scheme in use at Rothamsted, seems necessary in order to ensure the proper working of the scheme.



Mr. H. MORRIS (10.30).

The need of rural England is for a cultural and recreational life of its own which will release a frustrated countryside from dependence on the large towns (which themselves have not solved their own cultural problem and are largely at the mercy of a fruitless commercialised amusement). Can this be done? Yes; in terms, however, not of the individual village, but of the rural *region* comprising a number of villages served from a centre, which may be either a large village or a small country town. The principle of centralisation, which modern transport makes easy in practice, has already become national policy in the education of the older children in rural senior schools; a similar logic applies not less cogently to rural adult education and recreation. But the senior school conceded merely as an evening class centre is less than an amelioration. The countryside requires community centres on a generous scale and including accommodation set apart for adults which, in addition to housing the senior school in the daytime, will in addition provide a theatre for the habituation of the whole adult population beyond the school-leaving age in Science and the Humanities and in Health and the corporate life.

Prof. N. M. COMBER.—*Universities and education for rural life* (10.50).

1. University courses in agriculture have generally been regarded as suitable training for those who wished to seek technical or commercial appointments in the sphere of agriculture. Shorter and more elementary courses, with what has been called a 'practical bias,' have been regarded as more appropriate to those who are going to farm and earn their living on the land. The prestige and dignity of farming surely demands that those who are to pursue it should be given the fullest educational facilities. Moreover, it is eminently desirable that the education of the practising farmer should not be restricted, as it tends to be, merely to those matters of obvious utilitarian and financial significance to him, but should equip him to take his place in the cultural, social and recreational life of the countryside.

2. The proper developments of British agriculture and of the social life of the countryside are in large measure dependent upon the interest in and understanding of farming and country affairs by the nation as a whole. Universities with Departments of agriculture should, as a national duty, endeavour to place some appropriate agricultural course at the disposal of others than those who are going to farm. Particularly in the training of teachers does it seem very desirable to develop some understanding and appreciation of rural life and of the conditions of British farm homesteads.

Mr. T. S. DYMOND.—*Raising the school-leaving age* (11.10).

The attempt to adapt rural education to rural needs by introducing handicrafts and gardening into the curricula of rural schools has not arrested the decline in rural craftsmanship except in isolated cases. Raising the school-leaving age to fifteen is likely to accentuate the decline unless the schools are so reorganised that classroom teaching in senior schools can be progressively replaced by individual work, so that the children can learn to depend more and more on themselves and develop their individual aptitudes. Even so there are occupations into which certain children should be allowed to enter at fourteen, provided arrangements are made for some form of school continuation.



Mr. G. W. W. PIERCE (11.30).

The village school as it exists to-day is doomed.

The new rural school will be an area school of about 220–280 children, situated in the country—the more rural the better.

Eight to ten acres necessary in order to allow for playing fields and gardens.

The tendency for local education authorities to convey country children to the nearest town to be educated with town children is definitely wrong.

It is better for town children to receive a rural education than for rural children to receive an urban education.

The teaching staff must be interested in rural life and rural surroundings.

A rural bias is essential in all subjects of the curriculum, particularly arithmetic, gardening, science, handwork, cooking and geography.

Practical work is vital and should occupy at least half the school hours.

Sir ARNOLD WILSON, K.C.I.E., C.S.I., C.M.G., D.S.O. (12.0).

Education for rural life involves in practice education for husbandry in all its branches. This can only be given in rural areas by teachers, male and female, who know something about it and are convinced believers in it as a way of life as well as a living. Such persons are rare except in agricultural institutes. Little can be usefully accomplished in elementary schools: more might be done in secondary schools, but for practical purposes we must look to County Schools of Agriculture. But the first need is a different outlook upon husbandry in every walk of life and a reversal of present trends of thought in Whitehall and Westminster, at Broadcasting House and in Fleet Street.

## SECTION M.—AGRICULTURE.

Thursday, September 10.

DISCUSSION on *National nutrition and British agriculture* (10.0).

Sir JOHN ORR, F.R.S.—*The requirements for an adequate diet.*

Formerly dietary surveys took account only of proteins, fats and carbohydrates, and political measures were limited to the relief of hunger. It is now known that diet must also contain a sufficient amount of a number of minerals and vitamins. Calcium is probably the constituent most deficient in poor diets, and the only practical way to get a sufficiency of calcium is by increased consumption of milk. In practice a 'poor diet' is liable to be deficient in most of the minerals and most of the vitamins and, in the case of children, of first-class protein.

The 'London Report' of the Committee of the Health Section of the League of Nations states that an adequate diet for children and pregnant and nursing women requires  $1\frac{3}{5}$  pint of milk per head per day. To provide an adequate diet the milk consumption of the country would need to be double the present production, with similar increases for eggs, fruit and vegetables. The cost of an adequate diet (9s. to 10s. per head per week) is beyond the purchasing power of one-third of the community. There

is no difficulty about producing the food. The difficulty is in enabling the food to be purchased.

A short statement will be given showing the improvement which could be made in the national physique and the reduction in disease and the resulting saving to the State in health services, and the suggestion will be made that the Government, instead of having a purely agricultural policy, should consider the advisability of having a national food policy based on subsidised consumption and reorganisation of distribution, the main objective being to bring a diet adequate for health within the purchasing power of the whole community.

SIR DANIEL HALL, K.C.B., F.R.S.—*National nutrition and British agriculture : meat, general agriculture* (10.30).

Can a national policy for agriculture be framed that will fit in with the nutritional needs of the people? The desiderata are more milk and live-stock products, eggs, potatoes and green vegetables and fruit, all products eminently congenial to our soils and climate. All are relatively dear, the cheapest sources of energy being cereals and other grains, foods deficient in the necessary accessories.

Since this country produces less than two-fifths of the total food it consumes, a choice can be exercised between the commodities we import and those of which we will encourage the production at home. At the same time legislation has provided powers through which the course of farming can be adjusted to a national plan. On this basis the existing subsidies to the production of wheat and sugar are ill-designed. They are cheap in the world's markets; they are the easiest foods to import in time of war; land is being diverted to them that is better adapted to the production of live-stock and vegetables. The production of milk is already 30 per cent. in excess of its consumption as milk, but a high price to the public is being maintained to cover the loss on the conversion of the surplus into cheese, etc. As regards vegetables and fruit, the supply can be extended by diverting to them some of the assistance accorded to less desirable commodities. But as regards vegetables, milk and meat, reform is necessary in the methods of distribution and retail sale. The country is committed to planning in agriculture: what is needed is a comprehensive plan that will take the nutritional needs of the people into account.

Prof. J. A. S. WATSON.—*National nutrition and British agriculture : meat* (11.0).

The expansion of the milk industry, highly desirable in itself from the point of view of national nutrition, will obviously, other things being equal, tend to reduce the amount of pasture available for beef cattle and for sheep, thus tending to restrict supplies of mutton and of the better qualities of beef (i.e. of steer and heifer as opposed to cow beef).

The production of milk as at present carried on is associated with a very high wastage of cows. The cause of this is largely the heavy incidence of four diseases—bovine tuberculosis, mastitis, contagious abortion and Johne's disease. The importance of the wastage problem is obvious if it is considered that the ordinary life of a healthy cow is about eight or ten lactation periods, whereas the average life of the dairy cow is about three and a half lactations. A determined campaign for the reduction of disease would result in a decreased output of inferior cow beef and would leave



available a large amount of pasture, etc., for the production of mutton and of high-quality beef.

The other chief way to increase the output of meat is to improve our grasslands and subject them to a more intensive system of management. The work of Stapledon and his colleagues in connection with the improvement of mountain grazings is very important from this point of view. The substitution of alternate husbandry for permanent-grass farming would also lead to an important increase in the stock-carrying capacity of the land.

So long as feeding-stuffs can be imported in large quantities, there is no limit to the possible expansion of the pig industry.

Prof. H. D. KAY.—*National nutrition and British agriculture : milk*  
(11.30).

This paper is not concerned with ways and means of bringing about the increased demand for liquid milk adumbrated by the opener of the discussion, but with the ways in which British dairy farming could meet such increased demands, which would entail the doubling of the present total home production.

There is already an excess of production over present *liquid* consumption of approximately 33 per cent., nearly all of which, at present, is 'manufactured.' A part, but only a part, of this 33 per cent. could act as the first reserve.

A further increase of 100 per cent. in milk production in this country is undoubtedly possible, but it would probably require a decade or more to effect. A large rise in the number of dairy cows would be necessary, though part of the increased production might well be derived from a greater average yield per animal, which is at present far too low. Artificial insemination using proved sires would accelerate progress. There would have to be an increase (though it would be much smaller in proportion than the increase in the number of dairy cows) in the total area devoted to dairy farming, particularly in the area used for grass production. A much larger quantity of concentrated and other foodstuffs for the cow would be required, and very close attention would have to be given to developments in grass farming and the production of artificially dried grass—the latter might eventually meet a large part of the increased demand for concentrated foodstuffs.

Greater control of bovine disease would be essential, contributing eventually to increased milk yield per animal, increased length of milking life and improvement of milk quality. Payment for liquid milk on a quality basis is ultimately inevitable, 'quality' including chemical and nutritional as well as hygienic quality. A larger population engaged in dairying would result, but its size would not be in proportion to the increased volume of milk production. The optimal size of a dairy-farming unit would require careful scrutiny; for many reasons it would appear probable that the most suitable size for economic efficiency is, in land of normal quality, considerably greater than the present average acreage. Increased mechanisation is almost axiomatic.

In order that dairy farms should function efficiently to enable milk production to be developed as outlined, a wider and more intense dissemination of information regarding feeding, dairy management in all its branches, including the management of grassland, and cowshed technique would be required. Greatly increased demands on agricultural colleges and farm institutes would be expected. These demands might be met in part by



properly organised schemes of rural education, such as those suggested by the Agricultural Education Society last year. If it were found possible to arrange them, organised refresher courses, dealing mainly with modern developments, for established dairy farmers would be of great value.

DISCUSSION of preceding papers (12.0).

AFTERNOON.

Excursion to Messrs. H. Silcock and Sons' Thornton Hall Farm, Thornton-le-Fylde.

**Friday, September 11.**

DISCUSSION on *Economic problems of milk production* (10.0).

Mr. C. LAW.—*Milk production costs on a Lancashire farm.*

Taking as a basis the cost accounts on the writer's own farm, this paper discusses under various headings the principal factors affecting the costs of milk production in East Lancashire. After indicating some of the more important changes that have recently taken place in the methods of milk production, the writer describes his own farm and district, and how the milk is disposed of, and proceeds to discuss the principal costings items under the following headings: rents, changes in proximity values; labour, machinery employed, family labour, extra labour involved in the production of accredited milk; feeding costs, recent changes in feeding methods, possibilities of reducing costs by grassland improvement, use of dried grass, etc.; depreciation, losses due to disease and the part played by feeding and management in disease resistance; receipts from sales of milk, and discussion of the effect of the operation of the Milk Marketing Scheme.

Mr. J. L. DAVIES.—*Production of milk for the market* (10.20).

Prof. A. W. ASHBY.—*Some variations in conditions and cost of milk production* (10.40).

Three factors mainly determine the general level of costs of producing milk: (a) seasonality of supply; (b) proportion of total food requirements that may be supplied by grass in the form of either pasture or hay; and (c) the standard of hygienic quality required. But costs of production cannot be separated from methods and conditions of trading in milk, and it appears that the dominant factor in the determination of cost per gallon has been the price realisable by sales from individual farms or from groups of farms in given localities. Prices and costs are both set according to conditions of supply and the most important factor is the ability to obtain from the consumer or user the price necessary to cover the required conditions of supply. While there is a temptation to say that prices follow costs, it appears, on the whole, that original causation lies in the markets rather than in the field of production. Farmers have fairly close control of costs of production of milk, and although in this case it may be easier to move upwards than downwards, important adjustments of costs to prices can be made. With farm costs averaging 9½d. per gallon over the country, individual farms may show variations between 6d. and 18d. or more

commonly 14d. Many individual high costs are temporary and due to accidental factors. Average costs do not vary with marketing 'regions,' in several cases the averages for these regions run close to the figure for the whole country. It may be possible that one or two 'regions' will show costs generally or more or less permanently higher than the national average, but there are very few areas in which costs cannot be adjusted to lower price levels if that is necessary. There are factors making for reduction in costs, but these are more or less counterbalanced by demands for higher standards of cleanliness. Farmers endeavour to maximise total profits from their herds, and profits do not necessarily follow prices upwards or downwards, because of elasticity as regards methods of production. But when conditions of supply are set, these tend to set levels of costs, and these costs must be covered by necessary prices. Factors making for cost reduction are (a) increase in yield per unit of feed input ; (b) improvement in production of grass and increase in 'grass' in total feed supply ; (c) increase in size of herd. Reduction in rate of depreciation of cows is required and improved buildings and water supplies would raise the economy of feed and labour.

Mr. JOHN ORR.—*Economics of feeding for milk* (11.0).

A reduction in the cost of producing milk of a given amount is of more advantage to the farmer than an increase in its price by a similar amount. The cost of production is unnecessarily high on most farms. This means that the cost of feeding is too high. In the period from November 1, 1934, to September 30, 1935, over the whole of England and Wales the cost of food was 62 per cent. of the total cost of producing milk. Research has revealed that in four different parts of England, from Lancashire to Dorset, the average cost of 1 lb. of starch equivalent obtained from purchased cake and meal is 1.04d. There is no great variation from farm to farm. It has also revealed that in those areas there are farms where the cost of 1 lb. of starch equivalent obtained from grass is 0.25d., 0.27d., and 0.28d. That is, the cost of food from well-cultivated grass is only one-quarter of its cost from purchased cake and meal. On other farms, however, the cost from grass ranges from 0.79d. to 1.40d. These high costs arise from seriously imperfect cultivation and management of grass. In their fields farmers have the opportunity of producing the soundest food from the financial point of view. It is in their own immediate interest and in the interest of the country that they should make full use of this : in other words, that their own land should produce its utmost before they turn to the produce of other lands.

Mr. A. D. BUCHANAN SMITH.—*Breeding for milk yield and uniformity* (11.20).

It is not the function of the geneticist to determine the optimum yield of dairy cattle for any type of farming, but to advise the farmer how he may secure that yield with uniformity in his cows. There can never be a best breed of dairy cattle. High production and phenomenal yields can be justified by the fact that the germplasm of such animals can the most easily effect improvement on the average of the breed. This holds equally good for breeds with comparatively low levels of production. For the future, uniformity of production is to be desired in the application of the progeny test to bulls of a dairy breed.

The pedigree breeder should endeavour to improve his herd in stages

and fix characters separately. If other breeders have fixed other characters, he will then be able the more easily to incorporate them in his own herd.

The dual purpose type (beef and milk) has a certain justification. By suitable crossing immediate adjustments can be made to suit changing conditions both of production and market requirements. Thus a variety of breeds is an advantage to a country, but basal knowledge concerning the inheritance of milk yield is desired in order that in the future such adjustments may be made more accurately and more rapidly.

DISCUSSION of preceding papers (11.40).

AFTERNOON.

Excursion to Lancashire County Institute of Agriculture, Hutton.

### Saturday, September 12.

Excursion to farms in the Lake District.

### Monday, September 14.

PRESIDENTIAL ADDRESS by Prof. J. HENDRICK on *Soil science in the twentieth century* (10.0).

Followed by DISCUSSION on *Soil problems*.

DISCUSSION on *Soil problems* (11.0).

Prof. G. W. ROBINSON.—*Problems in soil classification*.

Soils may be classified in a variety of ways. The first problem is to decide what is to be classified, i.e. what is the soil-individual. There is now general agreement in regarding the soil profile as the individual; but some difference of opinion may exist as to the definition of the lower boundary of the profile.

Ideally, a system of classification should illustrate the genetic relationships of the material classified. The elaboration of a system of classification of soils is rendered difficult by the fact that it is the exception rather than the rule to encounter soils in which contemporary pedogenic factors have resulted in climax development. Complications are introduced by human interference and its consequences. Apart from objective difficulties, a comprehensive system of classification can be devised only when it has been possible to consider most of the existing varieties of soil.

In reviewing soil data, it is important to distinguish the relevant from the irrelevant. Published descriptions of profiles often give minute details which, although they may serve to recall field appearances to the actual observers, are not clearly significant for the purposes of objective definition.

Profile descriptions, in order to serve as material for studies in classification, should always include quantitative data expressing the proportion and character of the reactive colloidal material in each recognizable horizon.

The principal factors determining the course of profile development are: (1) the moisture régime; (2) the temperature; (3) the parent material; and (4) the vegetation. A provisional system of classification is outlined.



Dr. R. K. SCHOFIELD.—*The behaviour of soil moisture in the field*  
—*The soil as a water reservoir* (11.20).

A true picture of the soil as a water reservoir can only be obtained by determining the pore-space and its variation with depth, and finding under known conditions what percentage of the pore-space is filled with water. Where the soil is variable the determination of pore-space, sample by sample, though it adds considerably to the labour, is an important safeguard against the drawing of unwarranted conclusions, and may enable useful deductions to be drawn where moisture percentages alone can give nothing of value.

Not all the pore-space is capable of storing water for the use of plants. Some is of so fine a texture that, even at the highest suction that plant roots can exert (10 to 20 atmospheres or  $pF$  4.0 to 4.3 on the author's logarithmic scale), its water is not released. Another portion is coarse enough to lose its water by drainage ( $pF$  1 to 3, according to circumstances). There is rarely as much as 3 inches of available water stored in a foot depth of well-drained soil. Losses by surface evaporation must also be considered in estimating the storage capacity, particularly during long periods of fallow.

Dr. A. B. STEWART.—*Soil research and the farmer's problems of liming and manuring* (11.40).

The numerous methods which have been devised for the estimation of the plant food content of the soil may be grouped under (a) Field Experiments; (b) Pot Experiments; and (c) Laboratory Examination. An outline of these methods and of their relative advantages and disadvantages is given, and the present position in regard to the advising of farmers on the liming and manuring of their soils is discussed in the light of data which have been accumulated at the Macaulay Institute.

Field experiments have been laid down on different types of soil, and samples of soil taken from the experimental areas for pot and laboratory examination. The field and pot trials have been conducted on the lines followed by Mitscherlich in Germany, and the results used to check those of various laboratory methods. The volume weight of the soil is taken into account, and the laboratory tests, which are found to give the best correlation with field and pot results on a particular soil type, are then used in advisory work on similar soils.

The results of field and pot experiments generally show good agreement for the potash content of the soil. For phosphates agreement is not so good, and comparison indicates that the subsoil content may be a factor of considerable importance. In advisory work it is considered necessary to examine samples of subsoil as well as of surface soil.

No single laboratory extraction method affects the soil in the same way as does the growing plant, but it is found that, if the results of a laboratory examination of the soil are interpreted in the light of field data, past treatment, cropping rotation, etc., information can be obtained which is of definite value to the farmer. Such information can help him to avoid the wasteful application of unnecessary fertiliser ingredients, which a safe dressing of a complete manure may entail.

AFTERNOON.

JOINT DISCUSSION with Section D (Zoology) (q.v.) on *Scientific problems of the poultry industry* (Section D room).

## Tuesday, September 15.

Discussion on *Scientific aspects of potato-growing* (10.0).

Mr. H. BRYAN.—*Some scientific aspects of potato-growing, with special reference to the health of the seed.*

The main factor in successful potato-growing—provided the land is suitable for potato-growing and is uninfested with potato eelworm—is the use of healthy seed : by that is meant virus-free seed.

In no industry is so little attention paid to the quality of the raw material used—in this case potatoes planted as seed—and in no industry is the raw material of more importance.

The greatest benefit scientific research has bestowed on the potato grower is the discovery of the causes of the degeneration of the potato, the realisation that varieties do not perish from senile decay but through contamination with plant viruses, which are spread mainly, if not entirely, by certain species of insects.

The paper describes how healthy stocks of seed may be maintained in England with consequent increase in crop and reduction in cost of production.

Prof. P. A. MURPHY.—*Potato viruses and potato production* (10.25).

Prof. R. T. LEIPER, F.R.S.—*Eelworm diseases of the potato : problems and recent progress* (10.50).

Of the three eelworms known to produce disease in potatoes *Heterodera schachtii* and *Anguillulina dipsaci* are now well established and serious pests in Britain. *H. marione* is at present known only on potatoes from abroad, but the common practice of using exhausted soil from infested tomato greenhouses as garden loam is a potential source of danger to the potato industry.

*H. schachtii* and *A. dipsaci* are spread to new areas by seed potatoes, and administrative control of the sale of seed potatoes from infested lands is urged. The only recognised alternative is insistence on prolonged rotations extending to six years. Recent laboratory experiments suggest that soil infestation with *H. schachtii* can be greatly reduced, if not completely eradicated, by prematurely hatching the cysts either by chemicals or by the use of root secretions from meadow grasses used in a rotation, or by destroying the cysts by using dressings of calcium cyanamide much in excess of those previously suggested. The 'unknown' factor in 'potato sickness,' presumed to be related to the chemistry of the soil, has recently been shown experimentally by Carroll to be due to the invasion of the first-formed rootlets of the potato by the larvæ of *H. schachtii*.

## Discussion of preceding papers (11.15).

Dr. E. WYLLIE FENTON.—*Some aspects of man's influence on the vegetation of Scotland* (11.45).

The old vegetation of Scotland and the extensive forests are discussed. Climate may have played some part, but not the most important part, in the destruction of the forests. There is abundant evidence of man's destructive

activities. Wars, fighting and raids devastated the forests. Many wooded areas were cut down to exterminate wild beasts. Shortage of fuel also denuded many districts of woods. Grazing animals and burning of vegetation prevents natural regeneration of trees. Many formerly wooded areas have become derelict and of little economic value. Minor destruction has led to moving sand dunes. In certain areas there has been a decrease of heather and a corresponding increase in rough grass. The nature and extent of grazing cause changes, and certainly play an important part in the Moor Mat Grass problem. The bracken problem is also bound up with the biotic factor. Competition between broom and bracken is discussed. Man has to his credit draining of marshes, bogs or mosses, and breaking in moors or heather, and thus extending the area of agricultural land. Much of his destructive activities might have been avoided, and action to prevent destructive action in the future is advocated.

REPORT OF COMMITTEE on *Soil resources of the Empire* (Section E room) (12.15).

Concurrent with above :—

JOINT DISCUSSION with Section L (Educational Science) (*q.v.*) on *Education for rural life* (Section L room) (10.0).



# CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES

THE Conference was held at the Palatine Boys' School, Blackpool, on September 10 and 14, 1936, under the presidency of Dr. A. B. Rendle, F.R.S. In addition to a large audience, delegates representing seventy-two societies attended.

## Thursday, September 10.

DR. C. TIERNEY, Secretary of the Conference, reported that as a result of the incorporation of the British Science Guild into the British Association, the Alexander Pedlar Lecture would be offered annually to one of the Corresponding Societies of the Association or would be delivered in some centre outside London.

Dr. Tierney further directed the attention of delegates to the following extract from the Report of the Council, 1935-1936, which had been approved and adopted by the General Committee at its recent meeting.

*Corresponding Societies Committee.*—The Council resolved to inquire into the status of the Conference of Delegates of Corresponding Societies, and appointed a committee to consider and report upon this. The committee made the following recommendations, which the Council adopted :

(1) An active liaison between the Association and the Conference by the regular attendance of the General Officers at its meetings.

(2) A policy of mutual co-operation between the Conference and the Sections of the Association.

(3) Additional representation of the Conference on the Committee of Recommendations (*i.e.* by the President and one other member).

(4) The Corresponding Societies Committee to consist of the President and General Officers of the Association (as at present), together with not more than six of the Delegates to be nominated at the annual conference, one-third of whom (*i.e.* the delegate representatives) shall retire annually and shall not be eligible for immediate re-election.

It is assumed that the retiring President of the Conference would be eligible to fill one of the delegate vacancies occurring on the Committee.

Arising out of the foregoing, the Delegates resolved to recommend the following as members of the Corresponding Committee for the ensuing year in addition to the President and General Officers of the Association :

Dr. A. B. Rendle, F.R.S.

Dr. Vaughan Cornish.

Mr. T. S. Dymond.

Sir Albert E. Kitson, C.M.G., C.B.E.

Mr. T. Sheppard.

Dr. G. F. Herbert Smith.

*Note.*—The President and Officers of the Conference of Delegates are appointed by the Council.

ADDRESS ON  
THE PRESERVATION OF NATIVE FLORASBY DR. A. B. RENDLE, F.R.S.,  
President of the Conference.

Is it important or worth while to preserve our flora? What does the native flora of a country imply? It is the result of changes recurring through successive periods of geological and climatic changes involving depression and elevation of the land surface and alterations of distribution of land and water and of climate. A natural flora is merely a stage in a continuous progress; only by our own limited ideas of time can it be regarded as static; for instance, sinking of the water-table will lead to the extinction of marsh-loving species and in the long run change a mesophytic into a dry country flora. A flora is a page in natural history and the question is how far can or should we refrain from disturbing the natural course of events which we cannot materially hinder.

The flora of all settled countries bears the mark of the effect of the action of man and his crops and herds, and their removal at the present time would not restore the original flora. Too many disturbing factors have been introduced. Is it worth while to preserve what remains of an existing flora? Otherwise what should we or posterity lose?

The question is of world-wide interest. May I refer to two examples that have come under my own observation.

A classic example which those who have read A. R. Wallace's *Island Life*, still a standard work on geographical distribution, may recall, is found in St. Helena, an isolated island in the South Atlantic. It is a typical example of an ancient oceanic island, that is, one which has never been connected with other land-surfaces, and, from its remoteness and antiquity, it should afford a valuable object-lesson in the distribution of plants and animals. When discovered, early in the sixteenth century, it was covered with trees down to the edge of the cliffs and must have had, judging from what remained sixty years ago, a remarkably rich and interesting fauna and flora. Now the greater part of the island is rocky and barren. The Portuguese introduced goats, the greatest enemies to trees as they destroy the older ones and eat off the seedlings. Under the tenure of the East India Company from 1651 onwards the forests were recklessly destroyed for fuel or building. The natural protection of the soil on the steep slopes being removed the tropical rains washed away the fertile surface to leave a sterile clay marl or bare rock. In 1810 the Governor reported, *à propos* of the cost of importing fuel, the total destruction of the great forests. But instead of adopting means for the preservation of what remained of the natural flora large numbers of plants were imported from Europe, America, Australia and South Africa, which continued the work of destruction by successful competition with the native plants.

J. C. Melliss, in his account of the island in 1875, gives a list of the remaining animals and plants which is enough to indicate the great

interest of the original fauna and flora, described by Wallace as 'a kind of natural museum or vivarium in which ancient types, perhaps dating back to the Miocene period or even earlier, had been saved from the destruction which has overtaken their allies on the great continents'; he continues, 'it is only by the extreme ruggedness and inaccessibility of its peaks and crater-ridges that the scanty fragments have escaped by which alone we are able to obtain a glimpse of this interesting chapter in the life-history of our earth.' One of the most interesting features were seven endemic species of Tree Composites, forms characteristic of isolated islands and tropical mountain heights. Of these Bentham says 'although nearer to Africa than to any other continent these composite denizens which bear evidence of the greatest antiquity have their affinities for the most part in South America.' Other affinities of the original flora are with Madagascar and East Africa.

The destruction of native by introduced species is progressive, and it would be interesting to know how many of the species listed in 1875 by Melliss are still extant. When I visited the island in 1929 the obvious flora was a remarkable *pot pourri* of South African, Australian and European species, and though we went up to the high interior of the island we saw few of the Tree Composites—a pathetic sight was a fine specimen being effectively strangled by English gorse.

In 1933 I spent some time in the Bermudas, a very isolated group of oceanic islands. These have not the botanical interest of St. Helena. There is little variety of surface and a geologically recent depression has submerged the greater part of the original land. The islands are nearer the American coast, and in the track of the Gulf Stream which ensures their remarkably mild climate. They have been stocked from the south-east American coast and the West Indies but have developed a few endemic species, including a Juniper which still covers the low uncultivated hillsides, a Palmetto, a few shrubs and herbs and some ferns. Since the settlement of the islands in 1609 man has effected great changes in the vegetation. Felling of trees, clearing land for cultivation and recently for golf courses, and draining of the marshes has largely destroyed the original vegetation. A valuable timber tree, *Zanthoxylum flavum* (Yellow Wood), once plentiful is represented now by a single specimen preserved in the gardens of one of the many luxury hotels; a beautiful endemic evergreen tree, *Elæodendron Laneanum* (Olive-wood Bark), is threatened with extermination. An important factor in the destruction of the native vegetation has been the introduction of alien plants which have largely replaced the natives. In his *Flora of Bermuda* (1918), Dr. N. L. Britton lists 146 native species of flowering plants and about 300 introduced and completely or partially naturalised species. This replacement is still going on. Native species cited by Britton as frequent were in 1933 found only occasionally and some of the rarities seem completely to have disappeared. The islands have a quiet and restful beauty, but the attractiveness of their present flora is mainly due to introduced, not native, plants. Indiscriminate felling of the Junipers is now forbidden, but there seems no active local interest in the preservation in what remains of the native flora.

Is it fair to those who will come after us to leave them the opportunity



of studying the vegetation of isolated and therefore peculiarly interesting floral regions only from dried specimens preserved in an herbarium?

But does this criticism apply to our own islands? Are they not merely a piece of western Europe furnished anew from the continent after a period of comparatively recent glaciation? This is only partly true. A large proportion of our native flora is no doubt the result of post-glacial immigration from the continent. But we have recently recognised that glaciation has supplied interesting problems in leaving open isolated areas which served as places of refuge for some species. In his recent address on British endemics to the Botanical Section of the South-Eastern Union of Scientific Societies, Mr. A. J. Wilmott combated the theory of complete extinction of our original flora by glaciation, and associated various types of endemic species with successive glacial periods in which specially favoured localities remained unglaciated as homes of refuge.

The more intensively we study our flora the more we find minor differences of greater or less interest. Those of you who read the *Journal of Botany* will have recently seen an account of a new *Brassica* found by Dr. Elliston Wright on Lundy Island. It is allied to *Brassica monensis* Hudson, a native of our western sea-coasts. There is no reason to suppose that the plant is a new arrival. Lundy Island does not attract many botanists, and specimens collected some years ago have since been found in the late Mr. Hiern's herbarium (now at Exeter) but unrecognised as a novelty. The plant is very local on the island, the comparative inaccessibility of which will probably ensure its survival from the raids of botanists, its only serious enemy.

As editor of the *Journal* I have the opportunity of publishing records of intensive study of genera or species which indicate the possibilities of such investigations in adding to the detailed knowledge of our flora and in elucidating points in distribution in our islands and relations with continental forms. These supply further proof that our British flora is still a fertile object of study and worthy of preservation on that account. For instance, the *Journal* for the present year contains a revision of our British Euphrasias by Mr. Pugsley, an example of a critical study of the variation and distribution of a genus in a definite area, and a similar study by the same author of a plant familiar to all field-botanists—*Gentiana Amarella*.

The preservation of natural floras implies adequate records and there is still much to be done in relation to the British flora in this respect. The preparation of local lists affords employ for local Natural History Societies, and with the help of these a county flora may be prepared. Members of our South-Eastern Union have during the last seven years helped thus towards the compilation of a much-needed Flora of Sussex which has now been completed by Lt.-Col. Wolley-Dod. Such floristic lists are important from the point of view of plant-preservation, as they indicate by recording distribution through a limited area over a period of years the increasing frequency or rarity of individual species and varieties and therefore the necessity for protection in special cases.

Vegetational surveys may be of much interest from the same point of view. They illustrate the fact that the *status quo* of a flora may be naturally dynamic, not static. Mr. R. Good's recently published account of

the botany of the South Haven Peninsula, Dorset, indicates an interesting combination in a limited area of stable and unstable conditions. A comparatively recent accumulation of sand-ridges on the shore-line interfering with drainage from the immediate hinterland has produced a complex mosaic of successional unstable vegetation-states the record of which over a period of years will form an interesting study. The interest in such cases lies in the conservation of a changing not of an existing flora.

Advocates of wild plant conservation may find themselves in conflict with those who, with the best intentions, seek to remedy the destructive effects of man's action or even to improve upon Nature. I see no objection to re-establishing a species in an area where it has been destroyed as the result of human action if it is done with certain precautions and if an accurate record is kept. But the utmost care must be taken to ensure that the form re-introduced is the same as that which it replaces. But the introduction of species in presumably suitable places, but where they do not grow now and have never been known to grow, that is, attempting to improve upon Nature or perhaps with a view to amenities, is to be deprecated. Even if a record be kept it is introducing a strange element into a natural community the effect of which is uncertain. If no record is kept and the plant survives it is making trouble for future students of the flora and its distribution. Species are from time to time found in new localities, the Lizard Orchid, for instance, seems to be increasing its area of distribution in south-east England, and the interest of the study of its distribution would be ruined if well-meaning folk introduced it successfully in presumably suitable areas.

A question arises as to the introduction of species in new areas for ecological experiment which may give interesting scientific results. Such investigations should be confined to very definite areas and should be carefully controlled and recorded.

Generally speaking introduction by sowing of seed is to be deprecated. It is largely a waste of seed ; in most cases the seeds either do not germinate or if they do the plants cannot compete with the existing flora. Also it may be some years before the plant sown, even if it survives, becomes a noticeable feature of the flora, perhaps not until the original interest in the locality has lapsed. On the other hand the newcomer might be too successful and displace the original flora, or even develop into a nuisance. Moreover plants which delight our eyes may be anathema to the farmer. Indiscriminate broadcast scattering of seed is a foolish practice with nothing to recommend it.

I need not warn members of scientific societies of the danger or inadvisability of introducing alien plants into a flora. It is difficult enough already to decide sometimes whether a plant is native or alien and we would not add to the difficulty for those who come after us. To introduce, for instance, alien alpine on a British mountain is unscientific and thoroughly reprehensible.

I have tried to make out a case for the preservation of our native flora. How can this best be done? Various societies and individuals have worked and are working to this end. Before the War a Plant Protection Section of the Selborne Society started active propaganda and a bill was



prepared for presentation to Parliament but the War stopped legislative action. More recently 'Flora's League' initiated by Sir Maurice Abbot Anderson has popularised the idea, and the Society for the Promotion of Nature Reserves works to the same end. In 1931 the Wild Plant Conservation Board of the Council for the Preservation of Rural England (C.P.R.E.) was appointed. It represents a large number of interested Societies, Councils and Institutions, and meets at intervals for study and discussion of relevant questions. I am indebted to the Secretary, Mr. H. G. Griffin, for details of reports of the work, to some of which I shall refer.

The subject of Nature Reserves was so admirably dealt with by Sir David Prain in his address to you at the York Meeting in 1932 on 'Local Societies and the Conservation of Plant Life' that I need only refer you to this. Those of you who have visited Nature Reserves at home or abroad will appreciate their value as conserving special types of vegetation. The more we can do in this way the better, but the conservation of our native flora as a whole is a wider problem and needs the help of all in fostering a love for wild nature and in developing a public feeling for its protection.

Legislation and Education are two methods of approach, each of which have occupied the attention of the Conservation Board.

Under the Local Government Act of 1888 County Councils are empowered to adopt bye-laws for the conservation of wild plants. The most recent form of bye-law approved by the Home Office reads as follows :—

'No person shall without lawful authority uproot any ferns, primroses or other plants growing in any road, lane, roadside waste, roadside bank or hedge, common or other place to which the public have access.'

Bye-laws have been adopted by about fifty County Councils and a number of Town Councils. In May 1935 a circular letter from the Chairman of the Board was sent to each County Council urging that the fullest possible publicity be given to the bye-law and also the adoption of adequate measures to enforce it. A large number of replies indicated that wide publicity was being given by means of the local press, exhibition of notices at police stations and other suitable places, and distribution of copies to Urban and Rural District Councils, Schools, Boy Scout and Girl Guide organisations, etc. Prosecutions for uprooting were also reported.

Schedules of plants recommended for special protection in individual Counties, prepared by Mr. H. W. Pugsley, have also been considered and distributed by the Board.

The work of the Board has evoked some criticism, especially as regards its advocacy of the bye-law forbidding uprooting. It has been objected that this involves hardship to students of the flora and also prohibits the uprooting of herbs for use as drugs.

As regards students, a plant can be studied without uprooting it. We are in fact coming to realise that plants may best be studied as they grow and especially in their natural environment. It is far more educative to study a few plants in this way than to pull them up, cram them into a tin and take them home to press for an herbarium. A great deal of information about a plant may be obtained without uprooting it and if such a



course is necessary there is the permissive clause in the bye-law which may also be employed by collectors of herbs for use as drugs. In the latter respect Mr. T. F. Wallis of the Pharmaceutical Society tells me that dealers in drugs generally prefer those grown in quantity for the express purpose as offering a standardised product.

Much has been said as to the difficulty of enforcing a bye-law. This is admitted but as so much of the damage caused is due to ignorance or thoughtlessness the knowledge that an act is illegal does bring the matter under notice. And the average person, however ignorant and thoughtless, doesn't necessarily want to do a thing because it is forbidden.

Again it has been suggested that County and Urban Councils are among the worst offenders in destroying rural amenities. I grant that these bodies badly need educating—in my own district we have suffered. But we have a local Countryside Protection Society (affiliated to the C.P.R.E.) which keeps a watch over the Council and offers advice and tenders protests. We recently stopped a wholesale topping of trees by an unskilled workman—and our suggestion as to the course of a path to avoid sacrificing some trees was adopted.

Bird-lovers and botanists share a grievance against local authorities in the lopping of hedges and cutting of the grass verges along country roads. Lopping of the hedges is a matter for the landowner except in so far as they do not obstruct the road-view. The verges are the home of many of our common plants and their ruthless cutting by the local authorities in the spring or early summer is most regrettable. In March 1934 the C.P.R.E. approached the County Councils Association on the subject, but the Association, while sympathising with the Council in their desire to prevent the indiscriminate destruction of wild plants, did not consider it feasible for the highway authorities to take any action in the matter, especially in view of the provisions of the Corn Production Acts, with regard to the destruction of injurious weeds and the impossibility of expecting roadmen to exercise the necessary discrimination.

In view of representations from the British Association and the Wild Plant Conservation Board the C.P.R.E. has recently again approached the Association and suggested the postponement of cutting until July or the early autumn; also that cutting and clearing should be carried out only for a fixed distance from the metalled roadway. At the time of writing no official communication had been received from the Association, but it has been ascertained that from the point of view of the Highways Authority it is not a simple matter. Farmers ask to have the verges cut as soon as the plants are in flower so that seeds should not be dispersed; the postponement of cutting until July would allow the spread of injurious weeds. Moreover the verge provides a way for pedestrians and cattle and must therefore be kept clear, and it is also a margin of safety for motorists. It is however encouraging to note from replies received that some County Councils are alive to the importance of saving the verges. At a recent meeting the North Riding County Council decided to call the attention of the Highways and Bridges Committee to the necessity, so far as possible, of limiting the cutting down of plants in the byways and lanes, so as to preserve the natural beauties and flora. We are informed also that in Derbyshire the County Council cut only a certain portion of the

roadside herbage, and that the workmen were discriminating between injurious and other plants.

The Conservation Board has also considered means for the protection of wild plants on privately owned property and a deputation of its members, with representatives of other interested bodies, was received by Sir John Gilmour on behalf of the Home Secretary, in May 1933. The Board suggested that the model bye-law should be strengthened to cover privately owned land. The case for the Board and those associated with it was presented by the standing Counsel of the C.P.R.E. who showed the inadequacy of existing methods for dealing with the matter, namely 'Malicious Injury to Property Act,' Larceny Acts and Trespass, and it was proposed to meet the case by strengthening the model bye-law. In a carefully argued reply the Secretary of State regretted that he was unable to meet the Board's suggestions, the main effect of which would be the protection of private owners from trespassers, and this was beyond the power of the Municipal Corporations Act. The Secretary of State suggested the insertion of the word 'primroses' after ferns to get over the *ejusdem generis* rule brought in by the use of the words 'or other plants' after 'ferns,' and regretted that this slightly amended form was the utmost that can properly be allowed under the present law. This latest form of the bye-law has already been accepted by a number of County and other Councils.

Picking of wild flowers for sale is not prohibited by this bye-law, but in reply to an inquiry from a member of the Board, a well-known Covent Garden salesman stated that everything possible was done in Covent Garden to discourage picking and marketing of wild flowers. They refused to handle wild daffodils and blue-bells.

Prevention of uprooting of primroses, ferns and other wild plants for sale needs special vigilance, but we have reports of occasional prosecutions. Local warden societies would be a deterrent, and also posting of notices which might intimate results of prosecutions, as used to be done on the railway stations. Folks should refuse to buy roots from gipsies or hawkers who have almost certainly stolen the plants or dug them up on common land.

I do not think children's wild flower classes at local shows are harmful. One specimen each of a dozen plants with their common names is generally asked for, and my own experience is that children collect only common plants and they do not uproot them. If there are rare or otherwise protected species in the neighbourhood these could be barred in the instructions. It seems a pity to check an interest in Nature on the part of the children.

But at best legislation is only the next best thing. In an ideal community where no one wants for himself what should be for the common enjoyment, legislation will be unnecessary. Meanwhile education of the community is necessary.

Education of the average adult to respect our wild flowers may seem well-nigh hopeless. He is not interested. And thoughtlessness, even in those who should know better, is a frequent cause of damage. About the same time last spring two reports came to my notice. A field in the west of England, purple with fritillaries in the morning became merely a green sward towards the end of the day. It had been thrown open to the public, at 3d. per head, who were allowed to gather bunches of flowers,



the proceeds going to pay for the organ at the parish church. The report of a beautiful wood absolutely stripped of spring flowers coincided with a day's holiday at a large girls' school in the neighbourhood; the pupils were conveyed under authority to the spot and turned loose for the work of destruction. Unfortunately such occurrences are too well known to need further reference here.

The spirit of acquisitiveness, of getting something for nothing, is hard to fight. The gain too is often short-lived and scarcely worth while. To dig up primroses and plant them in a garden is less effective than sowing a few pennyworth of seed. Many of the flowers picked are withered before they reach home and if not they don't, as a rule, last long in water and, as any housewife will tell you, they drop and make a mess. It is of course the picking wholesale that should be discouraged. No one should want to prevent a child picking a handful of flowers, nor to forbid the use of wild flowers for class-lessons in schools. But wherever possible the school should have a garden which should, so far as possible, supply the material required for study. Let the children collect seeds, sow them and study the plant as it grows. Seeds of our wild plants are distributed to members of the British Empire Naturalists' Association, and of the South-Eastern Union of Scientific Societies by the seed exchange section of the Union managed by Mr. B. T. Lowne. The list of seeds available is published in the spring number of *Countryside*, the organ of the B.E.N.A.

Wild flower seeds may also be obtained from the Green Cross Society (47 Victoria St., London, S.W. 1), or from Mr. C. S. Garnett, 6 The Strand, Derby. Flora's League publishes a booklet by Mr. T. A. Dymes on 'Growing Wild Flowers from Seed.' His rules on practical methods, if followed, should ensure success. Mr. Dymes also insists on the advantage of this method for an educational herbarium, as specimens of a species at different life stages, or growing under different conditions, may be added from one's own rearing.

Schools may also obtain supplies of wild flowers from firms advertising in the *School Nature Study Journal*, which guarantee to collect wild plants only without risk to injury of the native flora.

The public press might be a more efficient help in propaganda, and advertisements of wild plants for sale, obviously uprooted without discrimination, or notices of excursions for picking wild flowers in choice localities, should be refused; the Conservation Board has on occasion protested against these when they have been brought to its notice. The B.B.C. have, at holiday times, begged the public to leave for the enjoyment of others what the individual is prone to take for himself. Effective work might be done in this way from time to time by selected speakers. Posters to attract the attention of the public have been widely distributed.

Education of the children is the most promising method. A memorandum, prepared for the Board by Professors Salisbury and Weiss, has been distributed by thousands throughout the teaching profession. The county lists of species, to which I have referred above, will indicate where plants of special interest, from their rarity or because they are in danger of extermination, occur in the district. Such might be the subject of a special lesson and the interest of the children enlisted in their preservation.



In the United States of America the Wild Flowers Preservation Society has issued popularly written illustrated circulars, descriptive of individual species that it is desired to conserve, and giving directions for rearing them from seed.

In South Africa many of the native species are protected and a series of coloured drawings of protected wild flowers has been issued by arrangement with the Wild Flowers Protection Society.

The great enemy of our rare species is the collector; the general public takes no interest in them, but the collector wants them for his herbarium; and I don't know how you can reform the collector. He knows he is doing wrong when he confiscates a single specimen or takes from a small patch of a rare plant not only for his own collection but for purpose of exchange. Increasing interest in the study of the mosses is, Mr. H. N. Dixon tells me, threatening the extermination of some of our rarer species because collectors want specimens for their own herbarium or to supply friends at home and abroad. I was once approached by some of our leading British botanists to reprove a serious offender who was making a British herbarium. I administered reproof but the individual almost wept his protests of innocence. He has long been dead but his herbarium remains a standing reproach to his attacks of vandalism.

To sum up. I have tried to show that native floras are worth preserving in the interests of science, and that our own flora is of sufficient interest, quite apart from its beauty, to merit conservation. In addressing a scientific meeting I have emphasised the botanical aspect of the problem but botanists are, I am sure, as wishful as anyone to preserve natural beauty. I have referred to three methods for promoting preservation: nature reserves, legislation, and education; and the most important of these is education. I am perhaps addressing only the converted, but the converted must become apostles if the movement is to grow and become effective.

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Dr. W. D. LANG, F.R.S. (*Communicated by Sir Albert E. Kitson, C.M.G.*)  
—*The Menace of Rubbish Dumping in Places of Natural Beauty.*

The method of disposal of rubbish is characterised by insanitation, unsightliness, and damage to places of natural beauty, with the rat-menace as the predominant danger.

Since the advent of cheap motor transport the nuisance has greatly increased. Old quarries, gravel-pits, sea-cliffs, stream banks, former water-channels and other places—once covered with beautiful and interesting vegetation, and full of bird-life—forming ideal picnic grounds, have been nearly or completely spoilt by being covered with tins, food-cartons, outworn parts of motor and other vehicles, old bedsteads and other discarded material of our civilisation.

Particularly mentioned are various parts of the Dorset coast in the Charmouth and Lyme districts, such as Black Ven, Butterfly Dell, Fairy Dell, and the mouth of the Char, some of these having geological sections regarded as classic examples by our own and visiting foreign geologists.

It is suggested that public authorities might by co-operation organise an efficient and adequate system to collect such refuse, burn all combustible matter in destructors, reduce tins and other utensils to smallest bulk by

pressure, and, in the coastal districts, dump the residue into the deep, a mile or two from the shore.

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### Monday, September 14.

Dr. C. B. WILLIAMS and Mrs. K. GRANT. (*Communicated by Captain T. Dannreuther.*)—*The Insect Immigration Enquiry, with special reference to the North-Western Area.*

Observations conducted over a series of years yield definite evidence of the migrating instinct of certain well-known species of butterflies and moths and indicate that the immigration takes place over a wide area and in a uniform direction.

The observations have been conducted by members of local scientific societies throughout England and Wales, and by lighthouse and lightship keepers who have rendered valuable assistance in collecting and recording the arrival of specimens around the coasts; the records, usually accompanied by specimens and essential information as to date, time, prevailing wind direction, etc., entered on special cards provided for the purpose, are sent to the Rothamsted Experimental Station, where they are analysed and collated.

There is, however, a lack of observers in the North-Western Area, where sufficient information is not at present available to confirm the extent of the migration and its prevalence and distribution; and members of local societies willing to assist are invited to communicate for further particulars with the Secretary of the Insect Immigration Committee (South-Eastern Union of Scientific Societies), Captain T. Dannreuther, Windycroft, Hastings, Sussex.

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The following resolutions were considered and passed by the Delegates :

To request the Council of the British Association to support the Council for the Preservation of Rural England in its endeavour to stimulate His Majesty's Government to consider and take action upon the Report of the Government Committee on National Parks.

To request the Council of the British Association to bring to the notice of the respective Councils for the Preservation of Rural England, Scotland, and Wales the increasing menace to health and amenity of rubbish dumping in places of natural beauty and scientific interest; and to request the said Councils to make representation to the responsible administrative authorities concerned with a view to its mitigation.

## DISCUSSION ON GENETICS AND RACE.

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(Prof. H. J. FLEURE, F.R.S., Dr. J. S. HUXLEY, Dr. G. M. MORANT,  
Prof. A. M. CARR-SAUNDERS, Prof. R. RUGGLES GATES, F.R.S.,  
Prof. F. A. E. CREW).

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JOINT DISCUSSION BY SECTION D (ZOOLOGY) AND SECTION H  
(ANTHROPOLOGY) ON FRIDAY, SEPTEMBER 11, 1936.

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Prof. H. J. FLEURE, F.R.S.—*Racial theory and genetic ideas.*

The newer concept of species makes it possible to consider both the origins of mankind and a classification of mankind in a new light freed from the limitation of requiring the sterility of crosses as a test of specific difference. The fact that human migrations from early times have had a scale, a range and a rapidity unknown among animals is another biological point of the first importance. We may give up both the view that mankind originated from a single pair or a small group and the view that the different groups of mankind originated separately from prehuman ancestors. Rather should we picture groups of beings on the threshold of a full human status, with probably differences within the group as well as between groups, scattered over a wide area as more or less mobile collectors and hunters forming a sort of human network over a wide area of the Old World, stretching at least through North Africa and South-west Asia. The persons in different parts of the network would probably differ, but almost any part might contain individuals similar in many characters to individuals in other parts. With increasing settlement and development of desertic conditions in North Africa and Arabia, some degree of isolation and a high degree of local intermarriage developed and no doubt different variations, at least some of them adaptive, occurred in different regions, so that—

(a) A number of small remnants of early types remained, sometimes perhaps degenerate as pigmies of the African and South-east Asiatic forests, as blackfellows in Australia, and so on.

(b) African, Papuo-Melanesian, Eastern Asiatic and North-western groups became distinct, while drifts to America from Eastern Asia added another chapter to the story. These may almost be called sub-species.

Characters, even those used in discussing so-called race types, are nearly always both genotypic and phenotypic. Stature is closely linked with environmental factors; nose form may have some such link, perhaps an indirect one. A penetration of characters from the north into the Congo Forest shows that stature diminishes more rapidly than nasal index increases along the zone of penetration. It is most probable that hot, wet conditions and poor food have prevented higher stature from persisting, but it has apparently been more difficult to alter the narrow nose, so we get an aureole



of fairly narrow-nosed people of short stature around the wedge of narrow-nosed taller people projecting into the forest.

Shaxby has shown that skin pigmentation grades closely from the Sudan to near the Arctic Circle, where Scandinavia yields the Nordic type, as it is called. Similar points might be made in respect of other characters; thus the pattern of the main mass of mankind may be said to be one of transitions in some respects between certain standards in Africa, Europe, Eastern Asia, Papuo-Melanesia.

A scheme based on transitions more or less under environmental influences is, however, not much more satisfactory than a purely geographical classification, for we cannot but be impressed by the fact that almost every population consists of disparate elements that reappear or persist side by side in a population generation after generation. We cannot treat an ordinary population as a unit to be described by giving means and standard deviations for each character. Those figures often are mere abstractions. We need to try to see how bundles of characters are grouped together, what bundles occur and seem to be transmitted as entities, and how the proportionate numbers with different bundles vary from district to district. For they do differ, and we can understand this better if we remember that each of us had, in theory, 32,768 ancestors about the time of the discovery of America, and 1,073,000,000 about the time of the Norman Conquest. As marriage was largely localised and few rural areas with persistent intermarriage had a population of 32,000 in the fifteenth century, we realise how much branches of genealogical trees must intertwine, and so how possible it is for an element, a group of characters, that got into a locality long ago through a good number of individuals to go on century after century in spite of some intermixture with individuals from outside, provided it has not to work against a Mendelian dominant. Needless to say, the bundle of characters need not be and is not exhibited by every member of the local group, nor is any claim made that all members of the group are of strictly localised descent. We are dealing only with proportions of a population. Another necessary *caveat* is that the interpretation of differences between localities has to be done with great reserve unless we know from skeletons a fair amount about the back history of the district's population. Fortunately, as regards Egypt, we have the knowledge, from the work of Elliot Smith, Morant and others, that there has been a persistence of a bundle of physical characters from predynastic days till ours. In our own country, in some areas once inhabited (c. 1900 B.C.) by the beaker-making people, the characters which distinguish their skulls are still found in certain cases among the modern population. In some areas of special isolation quite a number of people may carry and transmit a bundle of characters that seems associated with the very earliest population known from skeletal remains in Britain.

The recurrence of these bundles is more than can be accounted for by any estimate of the probability of recombinations occurring in the course of intermixture; persistence seems the more likely hypothesis, and the linkage of characters in a bundle is fairly obviously a feature.

We are, then, dealing with bundles of characters inherited more or less as such, diverse bundles often co-existing side by side. Even an interbreeding population therefore need by no means form a unit, and averages may mislead seriously. A pure race, with essentially uniform bundles of characters in all its members, probably does not exist; indeed it is better not to use the term race at all in view of its purified misapplication in political discussions as well as of the inherent biological difficulties attached to the use of this word.

Dr. J. S. HUXLEY.

*Race* in common anthropological usage has two main connotations. One is community of descent, the other is distinctness from other races. In general biology, the term is used mainly of geographically or physiologically isolated groups within a species; and, although the term has now been largely abandoned in favour of *subspecies*, the implication is that human races are of the same nature.

Further, anthropological use of the term dates from the time when it was believed that inheritance was of the blending type; if this were so, a mixed population would speedily approximate to a characteristic uniform type. This assumption has been shown to be incorrect by the establishment of the Mendelian basis of inheritance. After crossing, recombinations of every possible kind will continue to appear indefinitely unless some are eliminated by selection.

Again, the assumption that man's evolution has been by separation into discrete isolated units is incorrect, since migration and crossing have been operative for tens of thousands of years; so, whereas the evolution of most animal types is *divergent*, that of man may be called *reticulate*.

As a result, it is probably impossible to give a scientific definition of race as applied to man, since the term has connotations which do not apply in the human species. Some less question-begging term should be found. The immediate task before physical anthropology is to define human groups in terms of measurable characters and the correlations between them, on the basis of Mendelian genetics.

Dr. G. M. MORANT.

A broad distinction may be made between two kinds of definitions of race in man, and when considering these in relation to genetics our concern is rather with the implications than with the wording of the definitions.

Those of the first kind accord with what may be called the classical theory of race, and this is generally discredited to-day. It is supposed, according to this older type of theory, that after the crossing of groups of families of different origins for several generations the original elements which entered into the constitution of a particular population cannot be distinguished, and hence that such a population must be treated as a single group and compared as such, and undivided, with other similarly constituted groups. If no general agreement was reached regarding the definition of race, this was largely due to the difficulty of deciding on the stage of subdivision of the total species which could be used most conveniently to distinguish groups which might be called races. According to this first view, the descent of races, and hence the course of human evolution, can only be revealed by the direct evidence of the actual remains of the ancestral populations, and hence it encourages the study of skeletal material.

The alternative type of theory, which is now generally accredited in one form or another, had been mooted by some anthropologists before modern genetical theories were established, but these have since been supposed to support and justify it. According to this second view, populations of the kind considered are never mixed uniformly, but there is a general tendency for ancestral types to occur in every generation, though not constantly in the same family lines. It is claimed that these types can be recognised in individuals, and this admits the possibility of discovering the racial components of a population solely from a study of its living representatives at one particular time.



A definite pronouncement by geneticists in favour of one or the other of these views would not resolve all the difficulties faced by anthropologists in their attempts to define the concept of race, but it would go far towards clearing up the present chaotic position. It appears that the two cannot be reconciled and that for practical purposes one or the other must be chosen. It has been claimed that the second, or segregation, view, as it may be called, alone accords with genetical theory. Is this correct? and, if so, will geneticists explain the mechanism which favours the persistent appearance of the ancestral 'types' of the anthropologist after more or less random crossing has taken place for fifty generations, say? Answers to these questions will depend on the nature of the characters which are used to distinguish the 'types,' because these characters have been observed to make the clearest distinctions between the different varieties of man. Most of them are dimensions or proportions of parts of the skeleton, and no others can well be used in dealing with extinct populations. All the characters of this kind show continuous variation, and it seems to be probable that each is determined by a large number of genes, as has been demonstrated in the case of stature. Variation in these measurements may not be of any functional significance or selective value. Such characters are of far less general biological interest than some others, but their use is fully justified if they can be used effectively to trace human descent.

It may be noted that the statistical study of the measurements which have been used with greatest profit by the anthropologist does not encourage the hope that the 'segregation' view of race can be reconciled with the facts. If it were correct it would be anticipated that for particular modern populations of the kind considered bi-modal or multi-modal distributions would occasionally be found, though apparently they never are. Also, on the hypothesis discussed, intra-group correlations would be expected between certain characters, and these are not found. The largest samples available for European populations show an almost complete absence of intra-group correlation between hair colour and cephalic index, say, or between eye colour and stature. Some expressions of the segregation view of race presuppose that the modern populations of Europe have resulted from the intermixture in comparatively recent, and even historical, times of populations which were far more homogeneous than any which can be found in Europe to-day. But the metrical characters show quite conclusively that there has been a remarkably small change in the variabilities of established populations from early predynastic times in Egypt to the present, and also that there is no marked difference between the variabilities of so-called 'primitive' and 'advanced' modern populations in any part of the world. The statistical evidence suggests forcibly that the other—i.e. the group—conception of race is the one which can still be used most profitably, in spite of its present ill-repute, and if this is correct the process of classifying and tracing the descent of 'races' must depend on the small differences observed between the averages for different populations, while the individual is practically ignored. It is often assumed that this older view of race, which has few followers now except among those who have found that it accords with and even appears to be necessitated by the statistical evidence, has been invalidated by modern genetical science. I should like to appeal to geneticists for consideration of this point, and, if the verdict is unfavourable, for a clearer explanation of the objections to the view in question than any which appear to have been given yet.

Suppose that geneticists allow that the problems of human descent can only be solved by treating groups. The next question is: In what ways can groups be compared in order to reveal group relationships? The view



of the geneticist on this question will obviously be of value to the anthropologist. In considering it one must remember constantly that individuals and groups are different in nature and that they behave in different ways. This may appear too obvious to be worthy of consideration, but a failure to appreciate the distinction is in fact a fertile source of error. Mendelian genetics has shown conclusively that the theory of blended inheritance is incorrect as far as individuals are concerned. It has been repeatedly inferred from this fact alone that a theory of blended inheritance relating not to individuals but to the group characters of intercrossed groups must also be incorrect. But this assumption is quite invalid, and the inference regarding the group cannot be investigated so simply. I am still prepared to defend the old-fashioned theory that, as far as quantitative skeletal characters are concerned, the crossing of groups leads to blended inheritance, i.e. to the blending of the average values of the characters for the parent groups. A great deal of observational data may be brought forward to support this theory, and it seems to me that no valid objections to it of a theoretical nature have yet been advanced by geneticists.

Prof. A. M. CARR-SAUNDERS.

Historical evidence is relevant to the problem of genetics and race, though it can never be decisive and must be used with great caution. We can take groups which exhibit fairly well marked physical differentiation, and ask whether their accomplishments can be satisfactorily explained without supposing that they are also otherwise differentiated. We can also take groups exhibiting fairly definite cultural characteristics, and ask whether there is any reason to suppose that they have peculiar genetic constitutions. The problem is whether, after taking into account the known facts relating to the influences which played upon groups, there remains anything in the story of their fate, accomplishments and characteristics which appears to call for some further explanation and therefore to indicate genetic differences in the region of intellect, emotion, or temperament. The result of reflection along these lines is that attention is arrested by the persistence of temperamental traits which characterise certain groups, but the interpretation of these observations is very doubtful. Again the evidence derived from the formation of new nations in oversea countries within recent times can be brought into the picture. About the origin of these new and distinct groups we have fairly complete information, and we can ask again whether, in order to understand what has happened, it is necessary to have recourse to the hypothesis of genetic differences.

Prof. R. RUGGLES GATES, F.R.S.

Geographical varieties are well recognised among plants and animals. With regard to man, some writers have passed from the well-known fact that most human types are of mixed origin, to the indefensible position that human races do not exist. From a genetical point of view, if we apply the same criteria of species to man as are applied to the higher mammals, it is necessary to recognise the existence of several species of living man. Recent critical studies of African monkeys show various genera containing a number of species, each with several subspecies or geographical races. '*Homo sapiens*' is an anthropological convention, surviving from the time when intersterility was regarded as an essential criterion of species. Recent evidence indicates that the mongoloid, australoid, negroid and caucasoid types of man have been evolving independently since the beginning of the

Pleistocene. This confirms the view that they should be regarded not merely as geographic subspecies or races but as species.

Prof. F. A. E. CREW.

The classifications of the anthropologist relate to physical characteristics which, from what we already know of human genetics and by analogy, are in the main genetic characters. This being so, it follows that any classification of man by reference to hereditary characters which disregards principles which the science of genetics has shown to be correct, must necessarily be imperfect.

The suggestion that in its very early history mankind became divided by isolation, mutation, selection and inbreeding into the equivalent of geographical races or sub-species is in accordance with the demonstrated facts of experimental genetics. But the notion that the mingling of such, consequent upon the removal of isolation and inbreeding, leads through blending inheritance to later uniformity, is not. Such constellations of characters have necessarily become broken up and their ingredients shifted back and forth, combined and recombined.

The techniques of genetics should now be added to those of anthropology and genetic analysis of human differences and the correlations between them should be undertaken.

OPENING OF DISCUSSION  
IN SECTION I (PHYSIOLOGY)  
ON  
THE STRAIN OF MODERN  
CIVILISATION

BY THE RT. HON. LORD HORDER, K.C.V.O., B.Sc., M.D., F.R.C.P.

*(Ordered by the General Committee to be printed in extenso.)*

My time being severely limited, and others having already referred to the matter, I will spare you my thoughts—which are wholly complimentary to those responsible—concerning the ‘socialisation of Science’ implied by the introduction of this subject into your deliberations.

But it is a characteristic of mine to criticise the major premise before I examine minor premises, and so I follow my inclination to-day and look across and beyond such a conference as this, to the ordinary man and woman, just as, in my more customary sphere, I am prone to make my observations of the patient independently of the presentation of ‘the case,’ however learned and skilful this may be: sometimes corroborating and supplementing the diagnosis and sometimes traversing it.

From the early days of the primitive curse, life has always imposed its strain upon mankind. It is the penalty we pay for living at all. Philosophers have always assured us that we cannot have life without it. Indeed, they have assured us that some degree of strain is good for us. There is, however, implicit in the title of this discussion the suggestion that the stress of modern life has new elements, and is excessive.

We have to-day, in connection with this subject, a spate of talk; my inclination, as I say, since I cannot hope to stem it, is to step round it, and to try to make direct contact with the folk concerned, just as, in my daily work, when I am faced with a mass of data resulting from the exploitation of instruments of precision, I ask the patient, so soon as I can isolate him from the laboratory equipment, ‘Where does it hurt you?’ and then listen carefully to what he has to say.

His problem is perhaps much simpler than his dossier seems to suggest. A lot of those data were not really pertinent, though the very discussion of them added materially to his disability.

Deliberation and an apparent inertia opposed to excitement and, perhaps, panic—these things resolve many situations. They constitute a British trait, often misunderstood, often apologised for, but prone to be very effective. . . . Let me present you with a picture that is typically British.

That policeman, walking so slowly to the excited crowd that has gathered round a prostrate figure. He arrives at length, and the crowd opens: ‘Come along there, what’s all this ’ere?’ The little boy whose arm he seizes, though least concerned with the incident, is duly impressed by the force of law. A dozen contradictory voices strive to explain exactly how the murder happened. Pencil and note-book are slowly produced and are



as slowly used. Provocation and fatigue begin to operate ; the general interest has time to flag ; and the crowd disperses as the epileptic, quite accustomed to the experience, rises almost apologetically to his feet and walks away. The constable resumes his measured step and the mews is at peace again.

I do not suggest that this parable is inclusive of the whole position ; far from it. Direct contact with men and women, and a full use of the clinical method, do, undoubtedly, reveal the effects of strain.

These are not effects which can be measured by direct and exact scientific method—though the ‘vital statistics’ are confirmatory—but effects the indirect evidence of which is inescapable.

In the street the trained eye detects in the physiognomy of the people the early stages of that concern which, in the consulting-room and in the hospital ward, shows itself so frequently as the more established picture of ‘Anxiety neurosis’—unloading itself upon the digestion, the circulation and other bodily functions, which are really more sinned against than sinning.

‘Functional’ diseases, as against ‘organic,’ have increased, whether in the field of the nervous system proper, the heart and blood vessels or the internal secreting glands.

I must not stay to expand, or even to justify, these statements ; few, if any, medical men will contest them. In case after case a tactfully conducted pursuit after fundamental causes removes the screen of headache, insomnia, indigestion and fatigue, and the anxiety factor is revealed.

In the sphere of microbic infections, as I have pointed out elsewhere, we have new diseases for old. Preventive medicine has freed us from many of the severer epidemics, as also from many fulminant sporadic infectious diseases. Tuberculosis has come largely under control. But in place of such plagues as these, there is an increase in the incidence of those more subtle germ diseases which we call ‘sub-infections,’ in which the virulence of the microbe is low, whilst the susceptibility of the host is high. In many of these diseases the germ comes from within and not from without : ‘a man’s foes’ are ‘they of his own household.’ In short, we are becoming the victims of our own saprophytes. And the only reason we can assign for all this is a ‘give’ on the part of our own resistance to auto-infection—a ‘give’ which seems to follow a lowering of the control exercised in health by the nervous system.

Such control is, in a strict scientific sense, only a postulate ; it lacks proof ; but is it likely that, with nerve control of so many other functions proved, we shall find that the important function of immunity is an exception ?

So much for some of the effects of nerve strain. What of the causes ? It is almost platitudinous to speak of the anxiety connected with the competition of living, and now with the equally grave and increasing sense of international insecurity ; of the pace at which we live ; of the precariousness of life itself in the streets, so that we seem in these days to live by accident rather than to die by it ; of the monotony and drabness inherent in many workers’ long hours of physical and mental effort ; of the lack of air and of exercise and of sleep ; of the exciting nature of our amusements, whether the immediate demand for them be normal relaxation or a dope ; of noise—needless, stupid, provocative, ill-mannered, selfish noise. . . .

Platitudinous, and yet, on reflection the major premise holds good in respect of all these factors.

I would like to add another, more subtle, but none the less recognisable : the slackening of the moral code in the direction of increased freedom for

both sexes. I cannot summarise what I mean better than by quoting those two pregnant lines of Wordsworth's :

‘ Me this unchartered freedom tires ;  
I feel the weight of chance desires.’

In this sphere no doubt adjustment will come in time.

There is a notion afoot that, in the last analysis, Science is largely responsible for the extent and persistence of much of the strain of modern life. I want to say, at once, that I regard this unloading upon Science as a mere pusillanimity. I hold the view that it is not too *much* Science, but too *little* Science, that has helped to get us into this trouble. Or rather should I say, not enough interest *in* Science and not enough direction given *to* Science. What interest does the average individual really take in Science, and to what extent is he prepared to encourage it ? The answer is, almost nil. Which is odd when we reflect that he recognises quite fully—as how can he fail to do ?—that at the present time both politics and economics—and some would add even religion—regarded as systems existing for human betterment, seem to have failed him, and Science alone is not bankrupt. Science has, indeed, loaded man with benefits, but he has shown an indifference to them, or a carelessness and a prodigality in his use of them, which is quite pathetic.

A Spanish writer says, in this connection that, speaking for himself, ‘ . . . the disproportion between the profit which the average man draws from Science and the gratitude which he returns—or, rather, does not return to it : this is terrifying. I can only succeed [he continues] in explaining to myself this absence of adequate recognition by recalling that in Central Africa the negroes also ride in motor-cars and dose themselves with aspirin.’

Not only are we ungrateful in thought and attitude, but ungrateful in mis-handling the benefits accruing from scientific endeavour. Blame Science ? We need not drive a car so fast that it kills, nor make a loud speaker so loud that it deafens. Science was made for man, not man for Science, and the one thing that matters is control. Are we going to drive the machine or are we going to let it drive us ? Mr. Wells, in one of his inimitable word pictures, portrays civilisation as a high-powered motor-car gathering momentum on a precipitous hill, a quaking, gibbering monkey at the wheel, impotent to check its increasing speed. Not complimentary, but terribly suggestive.

And who cares about the direction along which Science produces her gifts to mankind ? We have an astronomer royal, but we have no biologist royal, still less a psychologist royal. Is this a survival from the days when we thought the stars controlled our destinies ? But if ‘ the fault is not in our stars but in ourselves, that we are underlings,’ as I believe it is, should we not ‘ do something ’ about this ? Hygiene of the body—the idea seems, at long last, to have been grasped : ‘ mental hygiene,’ after a long and painful labour, is, I think, being born : what of spiritual hygiene, the hygiene of temperament ? I believe that the spirit of man is fundamentally as amenable to scientific investigation, if not to control, as is his body and his mind.

I hope I shall not seem sententious in what I am now saying. It was the most doleful of the prophets who declared that ‘ the heart is . . . desperately wicked,’ but even he was not without hope about it. After all, the two essential desiderata were laid down thousands of years ago. ‘ Know thyself,’ said one of the ancient philosophers. ‘ All is in this, that thou govern thyself,’ said another. And these two things Science can, and doubtless will, eventually assist us in helping to accomplish. God may ‘ move in a mysterious way, His wonders to perform,’ but the mystery is



continually being made clear to us, and by Science ; slowly, of course, because, like Nature, who is but the material upon which she works, Science does not leap. There may be Design ; we know there is Law—cause and effect, ‘ the Chancellors of God.’ Genetic or conditioned, probably both, there are reasons why one man is sweet tempered and another truculent ; why one preserves his morale and another loses it ; why one is inclined to observe the Golden Rule and another is blind to its vast significance. We want to know the reasons, and Science can tell us.

Even if there be Design it is very unlikely that the pattern would be perceived by the scientist, however humble-minded—if such there be. The poet, perhaps . . .

Amongst the remedies for the ill effects of the strain of modern life, then, I place first more Science and especially Science directed towards the study and development of the mind and the spirit of man. Then it behoves us to guard and support all those amenities which are actually in existence or which are struggling for recognition : leisure for the artisan, the factory hand, the labourer, the shopman and shop woman, the housewife—and for ‘ all who grunt and sweat under a weary life ’ ; slum clearance ; playing fields ; national parks ; the National Trust ; physical education ; adult classes ; pictures ; poetry ; music ; museums ; libraries ; architecture ; quiet for the brain-worker and for others.

Whether our outlook be mainly that of the eugenicist or that of the environmentalist, we must not ‘ cease from mental fight ’ until we have, by these and other means, ‘ built Jerusalem in England’s green and pleasant land.’ I risk platitudes once more but again the major premise holds.

But the critic may be saying : ‘ That’s all very well ; you are only dealing with the individual ; it is the mass for whom you must prescribe, the mass that is arising here, and there, and that will determine the trend of civilisation in the near future, and even determine whether it continues to exist or not.’ But, personally, I see little hope for the people of this country through mass movements. Fascist or Communist, when individual freedom has been sacrificed I see no chance of achieving that control in the spiritual sphere through which alone, I believe, salvation can come to the human race. What matters the colour of men’s shirts if these are soon to be their shrouds ? Or what matters their numbers ? The falling birth-rate in this country is causing some people concern. As a disciple of Francis Galton I am much more interested in the quality than in the quantity of our people.

When the clash comes, if come it must, between these two hordes of the new barbarians—civilised barbarians if you like—it may well be that the salvaging of the world, or its doom, may depend upon whether Northern and Western Europe, and America, have been able to preserve an individualised Society, or, like the two opposed masses in the dictator countries, have yielded to the tremendous pressure of what may prove to be a bastard civilisation and have caught the infection of despair. If our own individualities refuse to be tub-thumped, or intimidated, into a pulp, all yet may be well and the clash may be averted. Meanwhile, “ a plague on both ” their blouses !’ We had troubles enough of our own with which we were busily, and not altogether unsuccessfully, coping : the loud-speaker next door, the roar of the sports model car up the street (night-silence for hooters notwithstanding) ; and now comes another fire-eating speech from a dictator on tour, or an account of one of these orgies of human sacrifice by which an executive hopes to maintain its precarious control. No wonder our nerves are kept on edge.

Much of what I have just been saying may sound like a statement of my



own views on international affairs rather than the contribution of a doctor towards the treatment of a disease. But I wanted to emphasise my opinion that remedies that depend upon parading or dragooning patients in the mass are spurious remedies, and are therefore unlikely to be finally effective in freeing the world from the strain that it is suffering.

Recently we have been witnessing the invasion of Medicine by mass methods, by direct action, by force. The results have been very disappointing. Too often we have had to admit that many of these therapeutic efforts did little more than demonstrate the triumph of technique over reason. We had to start all over again, working out the particular case, and following the indications carefully. That is, we did this if the direct action method still left us a patient to treat.

We remembered—what we never should have forgotten—that it is only by this segregation and study of the individual, and attention to his particular needs, that we have any good chance of restoring him to health. It is for this reason that I have dealt with mass movements as efforts towards restoring that sense of security which is essential to national and to international well-being. The analogy from medicine is all against treating the crowd and all in favour of treating the individual.

But it may be advanced that what may not succeed in Great Britain may succeed in Russia or in Germany. On this it behoves us to hold an open mind. But it also behoves us to be vigilant lest we sell the birthright of our national characteristic, which is individual freedom and poise, for one or other of the vaunted panaceas that are offered us from outside. I say all this at the risk of being charged with egregiousness—a common charge against Britons.

There is another characteristic in the British patient: to treat him successfully he must be treated through his intelligence and through his will, not through his emotions. He responds badly to the 'ça passe' method.

Nor shall we, if we be wise, listen seriously to the various panaceas offered to us from within. There are several of these. In respect of the worrying menace of war and the perpetual anxiety it creates, there is the doctor who says: 'Sign a post-card *against* war, say you won't *have* war.' Which sounds reminiscent of that old story, attributed to President Coolidge, who laconically summed up the preacher's sermon on sin by the statement, 'He was against it.' Or as who should say, 'I don't hold with cancer.' But who does? This sort of thing does not help anybody. Whereas the sentiment implicit in the question, 'Who stands if Freedom fall? Who dies if England live?' *does* help, nor is the man or woman who is braced by such sentiment necessarily a jingo or a blatant patriot. Ideals are essential for us all, and are invaluable tonics, but the British patient does better on a practical and an attainable ideal than on one which is, in this present world, too visionary. 'The test of truth in matters of practice is to be found in the facts of life, for it is in them that the supreme authority resides.'

Then, just as we get the hypochondriac in matters of the body and of the mind, so there is in some quarters, or so it seems to me, a tendency to spiritual hypochondriasis. There are folk who, to use Carlyle's significant simile, spend much of their time looking at their own navels, and even comparing them with those of their friends: much too subjective an occupation to be healthy. We break up the hypochondriac situation by exhorting the patient to be more objective in his outlook and to leave his body alone. His body troubles him less when once he effects this orientation. If for 'body' we read 'soul' the same result may be safely predicted from the same treatment. Following a medical thought I regard

these panaceas as being of the nature of quack remedies, because I do not think that they really deal with the facts inherent in the situation. We are asked if Soviet Russia can change human nature. Frankly, I doubt if it can, because I think the change must come from within and not from without.

And if we are given time, and given freedom from paralysing fear—Fear, the Arch-Enemy—we can reduce these strains of modern life by effecting a better adjustment in ourselves to the rapidly changing conditions of our times, reducing the pace at which we live, and achieving control. Given time to meet, and to know each other better, we can pool our various national traits. In the last analysis we are mostly good fellows with similar needs and probably with similar destinies.

It may be noticed that I have not attempted that most difficult of all considerations in regard to the patient—a prognosis. In this connection, I can only re-state my faith in the individual and in the enormous potentialities of the human spirit. Individual, did I say? After all, is it not a handful of individuals that guides the vast moral experiment now proceeding in the East of Europe, another handful that drills humanity in the centre and one individual alone who balances himself dramatically, as on a tight-rope, before the breathless crowd in the South?

And even here at home, who knows how much turns upon whether a prime minister's pipe is clean or foul, or if the head of the Foreign Office has had a sufficiency of sleep—so essential in the young, and especially in the young who possesses great gifts?

If doctors had political colour, like lawyers, it must needs be Liberal, and—I speak entirely without prejudice—I think a re-birth of that spirit in British politico-social life would be one of the best medicines that our strained lives could have administered to them.

When Browning makes Paracelsus say: 'Make no more giants, God, but elevate the race at once,' he seemed to subscribe to the element of charlatantry with which tradition debits that romantic figure. As I have already said, I do not think the cure will come that way. I believe that only 'man can elect the universal man.' But I have faith that the human heart *is* 'made of penetrable stuff.' I do not think that 'damned custom' has 'braz'd it so, 'That it is is proof and bulwark against sense,' though at this moment a morbid Hamlet, were he looking on, would doubtless take that view.

I think, rather, that there are still enough people, 'whose blood and judgment are so well commingled 'That they are not a pipe for Fortune's finger To sound what stop she please,'—enough of these sturdy folk to check the disease and to re-establish health. The treatment is the treatment of the individual by the individual. Any physician who can inspire 'Gentleness, Virtue, Wisdom and Endurance' will help to hasten and ensure the cure. Any physician who cannot prescribe such remedies obstructs the cure and should stand aside.

Is it permissible, in an assembly of scientists, to end on a transcendental note? If so, I would remind myself that the spirit of man, though often needing comfort and reassurance, and perhaps never more than now, is still the dominant factor in all the experiences that it meets, be those experiences in the bodily, mental and spiritual health of the individual or of the race.

'The Lords of life, . . .  
I saw them pass,  
In their own guise, . . .  
Portly and grim, . . .

Surface and Dream, . . .  
Some to see, some to be guessed,  
They marched from east to west :  
Little man, least of all, . . .  
Walked about with puzzled look.  
Him by the hand dear Nature took,  
Dearest Nature, strong and kind,  
Whispered, " Darling, never mind !  
To-morrow they will wear another face,  
The founder thou ; these are thy race ! " ' ,



# REFERENCES TO PUBLICATIONS OF COMMUNICATIONS TO THE SECTIONS

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# EVENING DISCOURSES.

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## FIRST EVENING DISCOURSE

FRIDAY, SEPTEMBER 11, 1936.

### SCIENCE AND ELECTRIC LIGHTING\*

BY

CLIFFORD C. PATERSON, O.B.E.

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THERE are here two lamps. A casual glance does not indicate any great difference between them. That is because one of them is one of the very latest products of the research laboratories of the industry of modern lamp manufacture. It is the latest born of a family of which the brothers and sisters are very different from this, for they have the most varied colours and shapes. We see some of them high up on buildings—long stems of different coloured light; others as brilliant sources lighting our streets with yellow or with greenish light; others in large reflectors floodlighting buildings with colours. The experience gained with all these other members of the family has in effect led research men to this latest simple and ordinary looking lamp. They are modern—these lamps—the new generation of the lighting world.

This other lamp is the youngest descendant of an ancient and illustrious line, an entirely different family, which started nearly sixty years ago at Newcastle, when Joseph Swan first showed how a fine stem of carbon could be made to glow in a vacuum when electricity was passed through it. His was one of the very earliest electric lamps. Since that day few industrial products have had lavished upon them a greater measure of scientific thought and research. This research has had for its object to obtain as much light as possible out of a current carrying filament, with as small an expenditure of electricity as possible. The result of all the effort has been to yield an improvement, of about ten times, of the modern filament lamp over Swan's lamp of sixty years ago.

Scientific research on the newer and more varied family of lamps is naturally being carried on with the greatest intensity.

I want first to use these two lamps to illustrate the two fundamentally different methods for producing electric light. In the one we obtain light from solids, in the other from vapours or gases. In the newer kind of lamps the light comes from vapour which becomes brilliantly luminous when electricity is made to pass through it. The inner part of the lamp is only a container for a very small volume of vapour contained in a space about 1 in. long and  $\frac{1}{4}$  in. diameter. A current has to be made to pass along this little enclosure. The secret of success has lain, of course, in learning how to do this with the materials which nature and man's art can put at our disposal. But we need not concern ourselves at the moment with how it is done.

\* Readers who wish to pursue this matter in greater detail are referred to the *Journal of the General Electric Co. Ltd.*, Wembley, Feb. (1937), in which the discourse is printed complete with illustrations, and from which reprints are available.

It should be observed that it is the vapour which carries the electric current. The current is led up to this metal termination, or electrode, and leaves again from this similar electrode, at the other end of the space.

Now, there is nothing in that space except molecules of vapour—in this particular lamp the vapour of mercury. When free molecules like this are compelled to carry electricity, they are at first somewhat reluctant to respond, but once they are put into a condition to respond they enter into the spirit of the thing with such excitement and vigour that their extreme activity is none too easy to control. The intensity of the light in this lamp is a measure of the vigour with which the molecules of vapour are responding to the conditions of stimulation which we arrange for them.

But the fact I want you to note is that the molecules will only respond in their own particular way and they show their peculiarities by the nature of the light they emit. Just as we can only get pansies from pansy seed and grass from grass seed, so does the mercury molecule, the oxygen, or the hydrogen molecule, or that of any other gas or vapour have its own characteristics. One of these characteristics is the peculiar composition of the light it gives out. A casual glance shows that the light from this mercury lamp has a special colour. If instead of letting the different components of the light come to our eyes as they are here, all jumbled together, we put them through a spectrograph, we can separate them and see precisely what are the colours which the mercury molecules are sending out and, when mixed up, give the particular colour which we see.

This spectrum—or analysed light—from mercury vapour, is intended to represent pictorially the same thing. It will be noted that the colours are the same as in the actual spectrum.

Here is the spectrum of a lamp in which the molecules of sodium vapour (instead of mercury vapour) are sending out the light. There is practically one colour only—yellow.

Here is the spectrum of a lamp in which the molecules of neon gas are emitting light.

This serves to show us what, from the point of view of the lamp maker, are the particular features of lamps in which electricity is made to stimulate the free molecules of vapours or gases. We shall return again to such lamps in a moment.

But what about this other lamp—the familiar incandescent filament lamp? This has a filament of tungsten metal which the electricity heats to a high temperature. Tungsten metal is also of course made up of molecules—tungsten molecules. Why do not the molecules of solid tungsten radiate light in the same kind of way as those of mercury which we have just seen? They clearly do not, as you can see from this spectrum of the tungsten lamp which contains all the colours shaded into one another. Instead of sending out light of a few isolated colours it has light of all colours of the spectrum from violet to red. The spectrogram would be exactly the same as this if the material giving the light were any other incandescent solid or liquid.

The reason is that the molecules of solid materials are not free, when stimulated, to radiate light individually. They become hot as the solid material which they compose is heated by an electric current; the elements of which they are made up try to move in the way they would move if they were in free space. But they are constrained and fail to do so. Their efforts are degraded into a confused radiation of all colours. That is why solids, when incandescent, are all very similar in the nature of light they give out. Their light is very similar to that of the sun, which comes from incandescent vapours and gases under extreme conditions of pressure.



This reference to the sun's light is by the way, but I mention it because its colour is on the whole what we like best for illuminating the people and things we ordinarily look at. The incandescent filament being a rough imitation of the sun's light also on the whole gives us satisfaction for illuminating purposes.

You therefore ask, why do we want to break away from incandescent solids, and employ these vapours and gases which seem to give such highly coloured light?

The reason is easy to see if we look at this diagram. When we make light by causing electricity to stimulate mercury vapour the upper part of the diagram shows what we are getting from the mercury for the money we spend on the electricity: a stream of green light; somewhat smaller streams of blue and yellow light; a trickle of violet light. There are also two other radiation streams which are not giving light, but which are nevertheless using up some of the electricity. One small stream is beyond the violet light. It is called ultra-violet, and we shall see in a moment how it can be used. The other stream is beyond the visible light at the other end and is called infra-red. This latter is heat without light; very little of it is wanted. The electricity which is represented by this heat radiation is mostly wasted. But you see what a lot of useful light we get for the electricity we pay for in proportion to the amount which is wasted as heat.

Now look at the lower diagram representing an incandescent solid—for instance, a filament. This shows what the filament gives us in return for the money we spend on the electricity which makes it white hot. The shaded part is the light we get. Look at the great torrent of energy wasted as heat and represented by the black area.

Some of these vapours and gases are able to give us much more light in comparison with the wasted heat than the incandescent filament can ever hope to do. We therefore get from them more light for the money we spend on the electricity.

That then is the lure of these electric discharge lamps. We like plenty of light and we like it cheap.

Before we examine some of the very fascinating things connected with new electric discharge lamps, I want to spend five minutes thinking about filament lamps. They, too, have responded to research and skill expended with the object of making them more efficient.

To make a filament lamp more efficient you can try to do either or both of two things. You can make the filament give out more light by running it hotter or, keeping the light the same, you can make it waste less energy by preventing it from losing so much of its heat.

Before the war, when we had this 'cage' type lamp, with its straight tungsten filament in a vacuum, we thought we had reached the end of lamp evolution. For tungsten, which is a most difficult material to work, has almost the highest melting point of any metal. It can therefore be run very hot, and no one could see how anything hotter, and at the same time more efficient, was possible. True, if the electricity were forced through this filament so as to bring it closer to its melting point, it became hotter, but the tungsten evaporated from the filament and the life was short.

Why not then put gas in the bulb instead of having a vacuum, and thereby prevent the molecules of the tungsten being evaporated off?

The lecturer proceeded to show by experiment that the introduction of nitrogen into a lamp bulb containing a straight tungsten filament, diminished the light emitted from the filament by abstracting heat from it; further, that forcing more current through the filament in an attempt to increase the light output made the whole bulb so hot that it threatened to collapse.

Here was where research came to the rescue. A very brilliant series of experiments showed the unexpected fact that if we coil up the filament into a small space the movement of the gas past the filament is far less effective in carrying away the heat than if the same filament is stretched out straight. So we can use gas to suppress the evaporation and consequent wastage of the tungsten, and still retain a much larger amount of heat in the filament.

Thus, here in this lamp is a similar filament wire coiled up into a fine spiral. It is amply brilliant. There is plenty of gas in this bulb, but the coiled filament is so much more retentive of heat in spite of the gas that we can heat it right up—hotter for the same life than when it was straight. When the lamp maker came to balance up the gain of light against the loss of energy by the gas he found he was distinctly to the good on the balance.

Let us illustrate this effect of the difference between a closely coiled wire and an open coiled or straight wire. Here is a closely wound coil of thick wire. As we pass electricity through it it rises to a red heat. The compact form prevents the cooling air having very ready access to its surface and it gets quite hot. But note what happens as we now straighten out the spiral. There is the same electricity, everything is the same, except that now the cooling air has far readier access, and the wire readily loses its heat to the air which is streaming across it.

Thus, we evolved the tightly coiled gas-filled filament lamp, and I hope its advantage can now be seen. It held the field for twenty years, in fact until a year ago. The coil of wire was extraordinarily fine, for it was necessary to spiral a yard of the finest wire into a coil only  $1\frac{1}{2}$  in. long.

You will already have been asking why, if this coiling improves things so much, we do not coil the coil, and make the hot element still more compact and therefore preserve its heat still more. This has now been done, but only after years of research—for the metallurgical and the electrical problems involved have been very baffling. Here is such a coiled-coil filament magnified. The larger proportion of the lamps made in this country for domestic use now have coiled-coil filaments and they give up to 20 per cent. more light for the electricity they use.

Before we leave the filament lamp I think you ought to realise the skill and craftsmanship which goes to the making of one of these filaments. Consider the ordinary 40-watt lamp which we all use in our houses. The metal tungsten out of which the filament is made is one of the toughest and most refractory of metals. It is so hard that it has to be drawn hot through diamond dies, which therefore have to be pierced with holes—perfectly round holes—no more than the size of a fine human hair, for this is the size of the finished wire. This wire diameter must be correct to within a half of 1 per cent., *i.e.* five millionths of an inch. Picture, therefore, a wire the size of a spider's web thread, accurate in diameter and beautifully round and polished—and think of the craftsmanship of the girls who do this drawing. As one of them described it to me, 'It is like threading a wire you can't see through a hole that isn't there.' This minute thread has then to be coiled with the greatest uniformity and equal precision, and this coil again coiled. Out of the 3,775 turns in the spiral of one filament not a single one must touch its neighbour, although there is only a space less than the thickness of a cigarette paper between any two turns. The whole diminutive structure has to carry electric current and stand being heated to within 25 per cent. of its melting point, and remain so for 1,000 hours without distortion. Such filaments have to be made by the thousand and such are your black looks if one occasionally fails prematurely, that failures before 500 hours' burning have been reduced to less than 1 per



cent. in the best makes. People think lamps are expensive! If the filaments were ten times larger so that they could be seen I believe people would think that they were worth more—notwithstanding the fact that they would be a hundred times easier to make. But the lack of gratitude in my fellows is not my theme this evening—so we will pass from the filament lamps.

#### ELECTRIC DISCHARGE LAMPS.

We saw just now that the enhanced efficiency of this vapour lamp was due to the absence of unwanted radiation.

To show that the efficiency is actually much higher we have these two lamps, a vapour lamp and a filament lamp, both using the same amount of electricity. I think it is obvious from inspection that the vapour lamp contributes much more to the total light than does the filament lamp. Actually, in the comparison before us the amount is about three times as great.

Now all vapours and gases are not so generous as mercury in the amount of light they give, so we have to choose carefully between them.

There is a somewhat subtle fact here which we have to remember. Your eyes and mine are not equally sensitive to all colours. Here is a figure which shows by the height at different colours how much more readily our eyes can see with a given amount of radiation in one colour, say yellow-green, than with the same amount of radiation with blue or red colour.

If we had two electric lamps giving out the same amount of light and both using a pennyworth of electricity a day, but one giving only blue light and the other only green light, the second one would appear to us to give five times more light than the other, because to our eyes, as we see from the diagram, the green light is more useful to see with; in other words, it seems brighter.

Here are the colours given out by the gas argon. You see the principal colours are in the red and violet end of the spectrum. There is also a little blue, but very little orange or green. Here is an actual lamp with argon gas in it. The colour is attractive, but you see it has not those colour elements to which the eye is more sensitive and the lamp in consequence is inefficient and on this account will hardly do for utility purposes.

Here, on the other hand, is an electric discharge lamp which, in addition to argon, contains some solid sodium. On first switching current on to this lamp the colour obtained is very similar to that of the argon tube we have just seen. If, however, we vaporise the sodium by heating it, the brilliant yellow light characteristic of sodium is obtained. The colour is far from attractive for general lighting but it is efficient, first because its colour—yellow—is one to which our eyes are fairly sensitive, and secondly because there is so little other radiation of a non-visible nature.

Here are a number of different gases through which electricity is passing. You see the large variety of colour which is possible, and can appreciate how it is that we have such cheerful colour effects in our city streets at night. For purely decorative work it is of course attractive to have as many colours as possible to choose from.

Some of these tubes are fairly efficient, especially when considered as creators of coloured light. Neon gas, for example, with its rich orange-red light is about three times as efficient as a tungsten filament lamp in a red glass bulb and giving light of about the same colour.

Each gas or vapour much prefers to operate alone. The presence of two gases or vapours in the same tube usually results in the suppression of the light from one of them.



Certain other additives—hydrogen for example—change the efficiency without much alteration of the colour. We have here a lamp with neon gas, fitted with a palladium tube for the purpose of admitting hydrogen. You will see when this is done that the light returns to normal as soon as the supply of hydrogen is stopped. Gases are not good mixers.

Of all the gases and vapours you have seen three stand out as the most promising ones to use if we want light to be abundant and cheap.

Cheap you say—yes, and what about the colour rendering of the human face? We have to go a step at a time. We have aimed first at high efficiency, and if this could be attained we have been confident that we could in time improve the colour. We will try to see how science and research have brought us, so far, in the direction of combining high efficiency with tolerable colour. I am going first to floodlight you successively with the light from sodium, neon, and mercury. Don't look at the lamps themselves but at your surroundings.

The sodium lamp is pretty bad and we don't yet know a good way of correcting its colour—which is a pity, for at present it is the most efficient of all. It gives out, as we saw, just yellow light, and all objects, including our faces, are a monotone in yellow-brown. When it is used at the relatively low illuminations which prevail in street lighting it is tolerable, and is being employed for this purpose, for which it has certain advantages.

Here is a colour chart which we will illuminate first by a tungsten lamp and then with a sodium lamp. It is obvious how such a lamp, used for general illumination, would take all the interest and colour out of our surroundings.

The neon lamp has been used for floodlighting red-brick buildings, for which it is particularly suitable, and for obtaining other colour effects. Its luminous efficiency is about the same as that of the familiar gas-filled tungsten filament lamp. The light is, however, almost completely deficient in green and blue rays and considered as a lamp for general illumination purposes, neon has little to commend it. It has, however, been used together with special green tubes for efficient interior lighting—lighting, that is to say, which must give reasonably faithful colour rendering—and which, by the way, must be just sufficiently unfaithful to the complexion to be flattering.

Owing to the high efficiency of the green tube used in these combined lighting units, the overall efficiency of the combination is approximately twice that of the tungsten filament lamps. But I would like to show you the beginning of something better—the result of some recent investigations. We find that if we coat the inside of a neon tube with a special luminescent powder, the activity of the gas in the tube excites the characteristic fluorescence of this powder. It therefore gives out light, light of the colour we want which, as it mixes with the red light from the neon gas, gives us a series of agreeable colours very suitable for interior lighting.

Here are three such tubes. The left-hand ends have been left uncoated so as to show what the light is like without the powders. In these coated tubes the presence of the powder not only improves the colour but doubles the light from them. The lowest of these gives a very fair white light.

Hitherto it was only found possible to excite fluorescence to an appreciable extent by direct excitation of the powder by the electrons of which the current consists, or else by means of the mercury discharge, which is very rich in ultra-violet lines. The great advance lies in the discovery that neon, which is comparatively poor in ultra-violet light, can in certain circumstances and with suitable powders be made to excite luminescence.

I want to return to these luminescent materials shortly. But before

doing so let us examine the last of the three most promising vapours or gases.

This is the mercury vapour lamp with which we are now floodlighting this hall. This in my opinion is the most interesting of the three, and we hope to demonstrate its considerable possibilities. The first thing you have noted is that it is anything but flattering to the complexion. True—and that is the worst of it.

If our complexions had no red in them and were blue or yellow it would do excellently, for mercury, as we saw, has both these colours. It has also violet and, still more important, ultra-violet. Red is all it really lacks. We see this at once when we turn the light on to the colour chart. You will note that yellows, green and blues all show well—only red is deficient. Thus, light from mercury—unaided by luminescence—is better than that from either sodium or from neon, on account of the greater variety of colours in its light. Let us pass the colour chart across the sodium, neon and mercury lights in turn. There is no doubt that mercury gives the most colour.

But one of the important advantages of mercury lies in the presence, in its radiation, of plenty of ultra-violet. This you will remember was radiation with a shorter wavelength than the visible blue—just too short to excite the seeing functions of our eyes. This ultra-violet radiation can be put to good use in exciting fluorescence. If the tube is not operated at a high temperature, the fluorescent powders may be applied to its inside surface, when the strong ultra-violet lines of mercury are able to exert their full effect. Here is such a tube. The right half of it is coated internally with a green luminescent material. The left half displays the mercury discharge without the addition of luminescence. The increase in light due to the fluorescence is in this case about eight times.

Now the glass walls of the intense mercury lamps (such as all here have probably seen in use for street lighting) are too hot to permit the powder to be applied directly. So in this case we must apply it to an outer envelope which does not become so hot.

We now know of luminescent materials which, when stimulated by ultra-violet light falling on them, will give out visible light having a red hue. If we coat an outside bulb with this material the useless ultra-violet light is converted by the powder into useful red light and the colour of the light from the combination is thereby improved. It is not perfect, but it is greatly improved.

Here is such an outside envelope coated with powder. Underneath it (and screened from you so that it does not dazzle) is an electric lamp using mercury vapour. Here is a length of multi-coloured cloth placed so that the light from the mercury vapour falls on it. We now lower once or twice the envelope over the lamp, and you will observe how the colour renderings are improved. There is no loss of efficiency when this envelope is in place because the powder adds as much new light as it absorbs of the original light falling on it.

These luminescent materials bid fair to play a considerable part in electric discharge lamp lighting. Whilst they have been known and used for different purposes for over a hundred years we are only now discovering how extremely bright they can be made, and how effectively the different methods of exciting them can be employed.

As an example of this I have an experiment here which shows how powerfully these powders can be excited by the electrons present in the discharge. The tube is coated internally with a powder. At present there is a gas in the tube and the electrons which comprise the electricity



and which are passing along the tube are absorbed by the gas before they can reach the coating on the walls. This is therefore only feebly excited by the discharge. By means of a charcoal side-tube, cooled in liquid air, the gas can be absorbed and thus removed from the tube. As the pressure falls the distance the electrons can move without being interfered with by the molecules of gas increases, until they are able to strike the luminescent powder on the walls with increasing force. The powder is then seen to be excited to a brilliant fluorescence, which stops as soon as the gas pressure falls so low that no more electrons are present. If the charcoal is heated again by removing the liquid air the sequence of happenings takes place in the reverse order.

Before leaving this interesting and important subject of fluorescence we should like to show some of the colours obtained by exciting these powders by a lamp from which the visible light has been removed by a special dark glass, thus leaving the invisible ultra-violet light only to come through. In order to show these effects in this large hall I have had the powders applied to sheets of cardboard, which we will now place successively in the beam of ultra-violet radiation. First of all here is an uncoated piece of white cardboard which does not fluoresce. This shows how little visible light comes from this lamp. Here is the powder with a reddish fluorescence which we have just used to improve the colour of the mercury lamp. You will observe how some of the powders continue to glow—or phosphoresce, as we call it, when the beam of ultra-violet light is cut off.

All this, I hope, shows that the resources of science are by no means exhausted in helping us, without using any more electricity, to add the missing colours to light given out by some vapours and gases, thus making objects illuminated under such light look as they do in daylight.

#### HIGH-PRESSURE MERCURY LAMPS.

But that does not finish the story of the mercury lamp and its possibilities. In the lamps we have been examining so far, the mercury vapour is at a relatively low pressure when the lamps are burning. When we speak of the vapour being at a low or a high pressure we simply mean that there are respectively a smaller or a larger number of molecules of the vapour filling the space in the tube and through which the electricity passes.

It was found four or five years ago that very great yields of light could be obtained from the passage of electricity through mercury vapour, if the pressure of the vapour were increased to about one atmosphere, as compared with about  $\frac{1}{100}$  of an atmosphere in the older types of lamp. Furthermore, research showed the way by which the higher pressure lamp could be made of simple construction. The result has been the improved lighting of hundreds of miles of streets in Great Britain. There are, in fact, some 20,000 street lighting posts now fitted with these lamps. I have one of these lamps here. They are well known now, but I would like you to look at this projection of the luminous part of one of these lamps. The naked lamp is too bright and too small to see properly from a distance, but the greatly reduced brilliance of the projected image gets over this. It should be noted how the discharge concentrates itself in a sort of central cord of luminous glow.

Now the increased intensity of this central luminous cord is the result of the electricity tending to confine itself to this narrow track, which it makes for itself through the molecules. The greater the number of molecules of vapour present (*i.e.* the higher the pressure) the narrower does this luminous cord become for the same electric current passing. This,



of course, makes the luminous cord intrinsically much brighter. We can in this way force electricity to make its track through denser and denser masses of molecules, with the result that we achieve brighter and brighter luminous cords. The temptation to push this process to the limit is thus very great, for although we do not necessarily obtain much more light for the electricity we use, we do obtain sources of light which have a most remarkable brilliancy—a quality which has important practical uses.

The tube containing the discharge naturally gets hotter during this process of forcing electricity through it, and we soon find that the keeping of this tube cool is the main problem before us if we would push the process to extremes.

Let us examine the phenomenon in stages. We are looking at the lamp in which the mercury vapour pressure is one atmosphere. The envelope is made from a special hard glass to withstand a temperature of about  $600^{\circ}\text{C}$ . It takes 10 volts per centimetre of arc column to operate the discharge, and the brightness is 150 candles per square centimetre.

Here is a small edition of the same lamp, using about the same amount of electricity but operating at a mercury vapour pressure of 10 atmospheres. The transparent envelope is of pure quartz, since the temperature now rises to about  $1,000^{\circ}\text{C}$ . It takes 50 volts per cm. to operate the discharge, and the brightness of the column is 700 to 800 candles per sq. cm., which is about five times as bright as the previous atmospheric pressure type. The bare lamp simply seems to have the same intense light as the previous atmospheric type; this, however, is an optical illusion. We can perhaps appreciate better the difference in the brightness of these two sources if we project their images side by side on the screen. On these images, the smaller one is about five times brighter than the other.

However, even quartz will not stand up to the very high temperatures it is possible to attain, and unless we make provision for adequately cooling the quartz envelope, the life of the lamp would be very short.

In the next example we help matters further by keeping the quartz cool with a stream of water. In this way we are able to dissipate still more power in the tube. The volts per centimetre of arc column are now 300 to 500, and the brightness reaches 30,000 candles per sq. cm., which is comparable with that of the high current density arc used for cinema projection and searchlights. We will look at the projection of its image first, it is above the other two. In comparison with the previous two lamps the greater brilliancy is obvious. We will now switch on a naked lamp. It does not do to look at it direct, or after image on our eyes may bother us for five or ten minutes.

When we tax the qualities of quartz to the limit we can reach 150,000 candles per sq. cm., *i.e.* 1,000 times brighter than our first lamp. This is comparable with the brilliance of the sun itself. But under these conditions the quartz lasts only for a few minutes or seconds, even when cooled with water.

Lamps of this type, when they become practicable, have one main purpose. Used in conjunction with mirrors or lenses they may take the place of carbon arcs and tungsten lamps for projectors—whether in aerodromes, cinemas or searchlights—where they may possibly have advantages over the lamps in use for these purposes at present.

Through the medium of these experiments I have been trying to picture to you the outlook at the moment of the scientific worker in the field of electric lighting. That outlook changes rapidly. We have seen that only during the past four years an increase of three times has been achieved in the amount of light obtained from a given amount of electricity. Secondly,

that during the same period the possibility has been demonstrated of making lamps of which the luminous component is certainly a hundred times brighter than the brightest filament previously available.

These are very considerable technical achievements in which this country has been a pioneer, and industry in this country is not being slow to exploit them.

Light is now becoming so cheap that it is folly to spare it, for its liberal use can contribute so greatly to safety and beauty in highway and garden, in our workshops and homes.

10 FEB 1937





# APPENDIX

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## A SCIENTIFIC SURVEY OF BLACKPOOL AND DISTRICT

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PREPARED FOR  
THE BLACKPOOL MEETING  
1936

*BY VARIOUS AUTHORS*

EDITED BY  
ARTHUR GRIME



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# A SCIENTIFIC SURVEY OF BLACKPOOL AND DISTRICT

I.

## PREFACE: A MODERN HOLIDAY RESORT

BY

ARTHUR GRIME.

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UNLIKE the city of Norwich, where the British Association meetings were held in 1935, Blackpool is strictly of modern growth. It was a mere collection of a few houses on a cliff, on the Fylde coast, in the Hundred of Amounderness, at the end of the seventeenth century. When the order for incorporation as a municipal borough was granted in 1876, the population was only about 10,000.

Growth in the intervening period has been phenomenal. Blackpool has easily outstripped Fleetwood and Lytham, neighbours which once regarded it as of secondary importance. It has now a resident population of about 125,000, and at the height of the holiday season is liable to be invaded by double that number of visitors.

Blackpool exists primarily as a holiday resort. Together with its near neighbours, it acts to some extent as a dormitory for professional and business men who are engaged during the day at Manchester and East Lancashire towns, but its chief revenues are derived from the savings of the people who come for health and pleasure to its shore.

Apart from one or two ill-defined residential areas, the whole of Blackpool is laid out for the entertainment of visitors. It has a few light industries, chiefly employing female labour, but there are few avenues for employment such as can be found in industrial towns of comparable size.

Blackpool's administrators keep steadily in mind its mission to cater for visitors. They were the first to extract from Parliament (in 1879) the power to spend on advertising the town a sum equivalent to twopence in the £ on the rateable value. Last year the Publicity Department had nearly £16,000 to devote to this purpose.



The growth of the town continues. Already Blackpool's buildings straggle almost continuously, but not quite, to Fleetwood on the north and Lytham St. Annes on the south. These towns will overlap before many years are past.

In the meantime schemes for the betterment of Blackpool are under unceasing consideration. A new Town Hall is badly needed. So are adequate parking facilities for the motor-cars which flow into the town every fine day in summer in embarrassing numbers.

By a rare combination of municipal and private enterprise, Blackpool has been made a prosperous holiday resort of world-wide fame in 60 years. The same persistence and ingenuity will be required to adapt it to the changing conditions of the past few years.

## II.

# 'AMOUNDERNESS,' A REGIONAL SURVEY OF THE FYLDE

BY

E. PRENTICE MAWSON, F.R.I.B.A., F.I.L.A., M.T.P.I.

'WE look backward that we may the better look forward' might well be adopted as the town-planner's motto. The present state of physical, economical and social development reached by this country, or, indeed, any part of it, has been brought about by a process of evolution dating back to the commencement of the Roman occupation, if not beyond.

Every regional planning report which has so far been published contains a lengthy history of the area under review, and a close analysis of existing conditions. It is only by such study that the possibilities and potentialities of the future can be envisaged and guided along proper channels, and conflicting interest harmonised.

It is a far cry from the Roman occupation of England to the present day, and yet the fact remains that the foundations of our arterial road system was laid by the Romans. So beautifully was this system adapted to the contours of the land, so perfectly were the roads planned in relation to the natural resources of the country and the linking up of deep water harbours, that some of our most eminent engineers have stated that if the system had had to be planned in modern times, *ab initio*, it could not have been improved upon. In several instances in the post-war period when new arterial roads have been planned and built, the foundations of Roman roads forgotten and covered with the debris of centuries have been unearthed.

Our castles, churches and monuments are heritages of the past. Our beautiful, ordered, rural scenery, with its hedges and trees, is for the most part the work of loving hands mellowed by time.

The growth of population and the exigencies of industrial development and modern forms of transport have created, and must continue to create, many problems difficult but not impossible of solution if we would preserve this heritage of natural beauty and archeological interest. The word 'amenities,' now so frequently used in Acts of Parliament, relating to town and regional planning, has a very real significance for all of us.

There are few areas so rich in antiquarian and archeological interest and with such a virile and continuous connection with the history of England as a whole as the ancient Hundred of Amounderness—a history which takes us back 2,000 years to the time when the area was peopled by the Setantii or Segantii, a branch of the Bregantes. They were not a building or planning community, however. So far as any traces of their occupation remain, they would appear to have had a few strongholds, but that is all. Their urns, tools, implements, canoes and so on are dug up at intervals all over the area, the principal discoveries being the following:—

|                            |      |      |  |
|----------------------------|------|------|--|
| STREET                     | .... | .... | Remains of Roman bridge.   |
| BLEASDALE                  | .... | .... | The Bleasdale circle, stockade and cinerary urns.  |
| LUND CHURCH                | .... | .... | Roman altar now used as a font.  |
| WESTON                     | .... | .... | Several urns, and pottery discovered on a barrow or cairn.   |
| WYRE                       | .... | .... | Cuirass picked up on the banks of the Wyre.  |
| KIRKHAM                    | .... | .... | Boss or umbo of a shield.  |
| VALLEY OF THE<br>MAIN DYKE | .... | .... | Two or three hide-covered wood-framed canoes.  |
| KIRKHAM                    | .... | .... | Roman coins.   |
| KIRKHAM                    | .... | .... | Roman pottery, stones, prepared for building eight or 10 urns (some cinerary), stone hand-mills, axes, horse-shoes.  |
| DOWBRIDGE                  | .... | .... | Ancient medicinal spring and roadway, urns and ivory needles.  |
| ROSSALL                    | .... | .... | 400 silver coins of Trajan, Hadrian, Titus, Vespasian, Domitian, Antonius, Severus, Sibia, etc.  |
| COGIE HALL                 | .... | .... | Oak box fastened together with oak pins, containing celts, arrow-heads, etc., now in Warrington museum.  |
| CLAUGHTON HALL             | .... | .... | Two large convex brooches to form a box to hold two beads of coloured paste and a mortar tooth enclosed in a wooden case. Also an axe and hammer, a stone axe maul head, iron spear head and iron sword, also an urn of baked clay containing charred bones. |
| VARIOUS                    | .... | .... | Celtic hammers, axes and spears taken from the Mosses in the district, also 'Druids' Eggs' or ornaments worn by the ancient British priests.   |



These show that they must have inhabited it in considerable numbers and for a long period, but the sites worth preserving are few, the most noteworthy being the Bleasdale Circle. Those interested will find a full account in the Transactions of the Lancashire and Cheshire Antiquarian Society for 1889 and 1900, Vols. XVII. and XVIII.; in the first, a short paper by the discoverer, S. Jackson, Esq., and in the latter, a full and complete description with scale drawings by Professor Boyd Dawkins, D.Sc., F.R.S., F.S.A.

While the Setantii did not plan, their name, and that given in very early times to the region they inhabited, give us a clue to the nature of the area as it was in the early days in which they lived, and of factors which then existed and which possessed such individuality that they have controlled and explain much that we find to-day in the region. Their name means 'the dwellers in the country of the waters,' and that of their country 'Amounderness,' from the Gaelic *Ac*, an oak; *Mund*, protection; and *Ness*, a promontory, clearly indicated that their country was a promontory densely covered with oak forests and protected by the sea on three sides, by dense forests on the higher and drier parts, and by bogs unpassable to anyone but those who knew them well, and were inured to considerable periods of immersion in water, thus giving them sanctuary, either from more warlike tribes, or those from which they had fled outcast.

And the same picture of our area is conjured up by what we find wherever the old peat deposits are cut in two. Under Marton Moss, for example, lay the remains of a great oak forest obviously felled in its prime by an inundation of the sea, probably accompanied by a furious hurricane; and elsewhere are indications of the same state of things: where land has been swallowed up by the sea, the stumps of a forest remain visible at very low water.

This is what the Romans discovered when they arrived, and bearing this in mind, there has always been a large element of scepticism on the part of modern antiquarians as to the Romans ever having set foot in the area, notwithstanding the fact that it has been littered all over with Roman remains. The position would seem to be this—What should the Romans want to come here for? If there are Roman remains, surely they may be accounted for by the fact that Roman methods of life were adopted by the Britons?

All the known facts, however, seem to be against the opposition, because in a close examination of the region we find so much in conditions as they are to-day which is most easily accounted for by the more popular tradition that Romans did come here. Indeed, we find the key to the whole position in Ptolemy's map of the coast, which gives us substantial grounds for supposing that the Roman port, '*Portus Setantiorum*,' known to have existed in the neighbourhood, was in fact at a point where the channel of the River Wyre discharges into Lune Deep, as the measurements he gives correspond more nearly with that position than with any other. We have this further fact to our aid, that at this point the channel has a vertical wall. Local navigators confirm this by the confident assertion that there is a masonry wall, the remains of a big wharf now sunk beneath the sea. Local antiquarians, on the other hand, postulate an outcrop of rock with a vertical face, either of sandstone like the neighbouring Preesal Hill, or limestone found a few miles away at and around Warton and the Carnforth district. In either case we



have corroborative evidence for the position as the site of '*Portus Setantorium*.' If there is a massive masonry wall there, no one but the Romans could have built it. If, on the other hand, before the sea encroached beyond it the rock foundation provided an almost perfect natural wharf, with deep water approaches and, at its eastern extremity, safe anchorage, in the (then) estuary of the River Wyre, what more likely than that it would be seized upon by such eminently practical colonists as the Romans, especially in view of their policy of conquest and colonisation of Ireland.

#### DANE'S PAD AND KATE'S PAD.

I have dwelt at some length on the point of the position of the Roman port because, if it existed, it solves so many problems as to the nature and meaning of other features. The chief of these is that artificial ridge elevated above the surrounding moss, of which little remains to-day, but which was undoubtedly used by the Danes in their incursions on the coast as a highway, and which to this day is known as Danes Pad<sup>1</sup>. The late John Just, in a paper read before the Historical Society of Lancashire and Cheshire in 1850 said: 'Within a mile of the town of Poulton-on-Fylde are seen the first indications of the Roman road, connected with an occupation road from a farmhouse which stands south-east of the town down in the valley . . . But having got on to the high ground and to a part of the flats of the Fylde district, we meet the striking remains of a road on the turfy ground, where it has been piled up in an immense bank or agger, and serves, as it has done for years past, as a gravel bank for getting materials to mend and keep in repair the common road of the country. Across this mossy flat the line is very distinct, and as therein ditches separate the fields in lieu of fences, frequent sections of the road are made, particularly by the water cuts made for the drainage of the district years ago.

'On the higher ground the whole line has long been obliterated and we are not favoured with any other evidence of the course it has taken until we again detect it in a low hollow towards Weeton Moss, which has not come within the influence of the general drainage just mentioned. Here is an immense embankment of several yards in height, its base standing in the water, which cannot get off from the isolation of its position.

'Then over the higher ground, which is dry, we can observe but slight traces of the road in the gravelly substratum it has left upon the ground until we reach Weeton Moss, where again we have a good specimen. Here too, modern plunder is fast despoiling the laborious workmanship of the Romans. The gravel seems to have been brought from the debris of some river. The line hence directs itself up the rising ground to Plumpton, and as usual in this part, the line has been mainly obliterated by the cart and plough of the modern. From Plumpton, it directs its course to the windmill on the high ground between Weeton Moss and Kirkham, which there opens to the view. Slight tracings all along verify the track the road has taken. Near the windmill the road forms an angle, and thence joins the public road in a long, continuous straight line towards Kirkham. Numerous Roman remains may be detected in walking along the side of the modern road. The modern road diverges to the right at the foot of the hill, and the Roman road continues

<sup>1</sup> See Map on page 59.

straight forward through the well-cultivated fields to Kirkham without a single trace having been left on the ground. About midway within the long town of Kirkham, the line of the Roman road falls in with the main street and continues up to the windmill at the top of the town.'

The whole description, too long to quote here, goes on to trace the road through Clifton Church and thence to Fulwood, though, as he says, the evidence for this portion is slight.

Porter, in his 'History of the Fylde of Lancashire,' published in 1876, completes the route sketched by Just in the above quotation, when he says :

'At the shore margin of the warren of Fleetwood, there was visible about 40 years ago (*i.e.*, 40 years before 1876) the abrupt and broken termination of a Roman road, which could be traced across the sward along the Naze below Burn Hall, and onward in the direction of Poulton.'

These quotations would seem fairly conclusive were it not for the fact that local archeological opinion has varied in a totally different direction since they were written.

J. Burrows, Esq., the present local representative of the Ancient Monuments Board, writing to the author in January, 1934, said : 'With regard to Dane's Pad, the only evidence that exists relates to a raised path, probably of neolithic age, which stretched in Porter's days from near Weeton Railway Bridge across the valley of the Main Dyke to Mythop. It has long since vanished.

. . . All the rest of the "Roman Road" from Ribchester to Poulton rests on the imaginative accounts of Just and Thornber, both of whom were without any status as observers. The rest of the authorities are mere quoters from Thornber. The late Mr. Clemesha and I actually walked over the whole of the alleged route, armed with the 6 inch Ordnance Survey Map, and nowhere found the slightest resemblance on or under the ground of a paved road.'

The finds referred to are the existence of a made road and the abutments of a bridge across the Dow Brook close to Dow Bridge, together with the ancient medicinal spring, which have already been mentioned, all palpably very old and generally popularly assumed to be Roman.

Whilst there is a conflict of opinion, the questions involved bear witness to the only point really material to the subject—that there was in, and possibly before the Romans came, a great elevated track, mound earthwork or causeway, giving a dry and elevated road across the marshes, in those days feet deep in water in parts, and that it connected the natural broken ridge running east and west, through Kirkham with Poulton-le-Fylde and the peninsula on which Fleetwood now stands.

While this track may not account for the existence of these two old towns, often referred to as the northern and southern 'capitals' of the Fylde, there can be little doubt that its presence has resulted in both their permanence and importance throughout the intervening ages, until the draining of the marshes, followed by the making of the railway, gave them a fresh lease of life as railway junctions.

There was undoubtedly another track of great antiquity across the area, called locally Kate's Pad<sup>2</sup>, and there would seem to be more general agreement

<sup>2</sup> See Map on page 59.



as to its origin as a Roman engineering feat, but its general route only is known as, although Thornber said in 1837 that large stretches of it existed in the then memory of living man, it was across the peat marshes, and, being a kind of 'duck-board' walk elevated above the water on piles, the peat cutters have entirely removed it. Porter says that it ran across the mosses of Rawcliffe, Stalmine and Pilling, and Mr. Burrows, the present authority, says that it ran from the high ground near the ends of Aldwath (the old name for the ford which existed near the site of Shard Toll Bridge) towards Cockerham. Being of a lighter construction than Dane's Pad, and therefore liable to destruction at points along its route from time to time, it is quite evident that it would not influence the original planning of the Fylde to anything like the same extent. A description of the earliest road system of the area would, however, be manifestly incomplete without its mention.

Two other ancient roads, of which only traces remain and almost certainly of Roman origin, crossed the area in a north-westerly and south-easterly direction, the one connecting Lancaster with Preston, and the other Lancaster with that 'Clapham Junction' of the Roman transport, Ribchester, or to give it its Roman name, *Rigodunum*. It is only necessary to add that, of the Roman bridge shown on the route of the more easterly road, only the abutments remain. Their authenticity is, I understand, quite unimpeachable.

Those parts of the general history of the Fylde, from the close of the Roman occupation to the more settled periods following the Stuart wars of succession, are one long series of growth and expansion of a particularly fertile and naturally prosperous district. But these settled periods were unfortunately alternated with barbaric destruction by one invader after the other, beginning with the Danes and persisting with distressing regularity to the days of the Roundheads, Cavaliers, Jacobites and Royalists. The fact that the district was so much less affected by the spirit of the Reformation can perhaps be accounted for by it being peopled to a large extent by persons of the Roman Catholic faith, and therefore Jacobite sympathies undoubtedly accounted largely for this and for the fact that settled and uninterrupted opportunity to make the most of the fertility of the soil and the mild and equitable climate, was only possible fairly late in its history.

How things stood at the time of the Norman Conquest may be seen fairly clearly from the fact that all the local place names in the Domesday Book (that wonderful prototype of all modern regional surveys) represent places existing to-day, and, moreover, if we accept the Fylde Coast pleasure resorts of recent creation, those still of the greatest importance. Only two churches are mentioned (three in the whole of Amounderness), those at Kirkham and St. Michaels Wyre, but a third at Poulton-le-Fylde was erected very soon afterwards, even if it were not in building at the time.

'The rest are water' says the Domesday Book, and, if the areas attached to each 'vill' in carucates is totalled and subtracted from that of the region as a whole, it will be seen how very large a proportion that water was. The Romans had doubtless begun the work of clearing the forests and draining the marshes, but it was not completed for a long time. Since then many valuable screen plantations have been planted and come to maturity, but much still needs to be done in this direction, and the preservation of that



which exists, and all that can be done towards the encouragement of further planting should be a part of every statutory town-planning scheme for portions of the region.

Turning now from the history of roads, and of the centres of population dependent on them, or rather mutually dependent upon one another, to the equally important subject of history as expressed in ancient buildings, one's mind goes naturally, first of all, to the area's only outstanding medieval fortress, Greenhalgh Castle. Secondly, the Premonstratensian Abbey of St. Mary-of-the-Marsh, known as Cockersand Abbey, which, whilst perhaps just over the border line of the area under review, *i.e.*, the Fylde, nevertheless belongs to the ancient marsh area. Sufficient remains of both the castle and the abbey to form conspicuous and interesting features in the area.

Greenhalgh Castle, originally a fortress, took the form of a square with a tower at each corner similar to that of which the ruins remain. It was erected by Thomas, Earl of Derby, as a protection against the outlawed barons and their outlawed and cut-throat followers under the depositions following the rebellions of that period. It led effectively to the pacification of the surrounding country, and remained until the Civil War, when it withstood a siege of two years in the Royalist cause. By 1649 the castle had been dismantled and lay in ruins.

Cockersand Abbey lies near the estuary of the Rivers Lune and Cocker, on the verge of the shore. To this day the site is very remote, and lies away from the main roads. In earlier days access was even more difficult and dangerous. Founded in 1190, it takes its origin from the hermitage founded in 1180 by Hugh Garth. The hermitage gave place to a hospital for the infirm and lepers, and belonged to Leicester Abbey. It was given to the White Canons of Croxton, who first founded a priory which was confirmed by Pope Clement III. in 1190, and within a further 10 years rose to the status of an abbey. The only part of the building that now remains intact is the chapter house, which appears to be the only example of octagonal form in a Premonstratensian house in this country. A full account of the abbey is given in the 'Transactions of the Lancashire and Cheshire Antiquarian Society,' Vol. XL.

Most of the places mentioned in the Domesday Book became the seats of families who ruled their neighbouring country for many generations, and in a few cases, at least, such as the Cliftons, of Lytham Hall, and their collaterals persist to the present day.

It is not, however, with the persons as with their seats and other buildings of historical interest for which they were responsible, that such a survey as this is most directly concerned. The outstanding fact seems to be that, most unfortunately from the archeological and artistic points of view, most of them have either been pulled down and re-built as farm houses, sometimes of a deplorably utilitarian kind, or have been re-faced with stucco and modernised internally, and thus have lost their original aspect so completely as to be almost incapable of restoration, even if the owners wished it. But some of them retain enough of their original character externally, such as Lytham Hall, Hackensall Hall, at Knott End, Naine Hall and Burn Hall, to be of the greatest interest to the artist, architect and antiquarian.

The uninformed enquirer might naturally suppose that in this part of the country, untraversed as to its western portion by any of the great through routes of traffic and surrounded on three sides by water, on two of which, though fording would be possible, it would be very difficult, and in the third by the open sea, we would have found a sleepy backwater which would have allowed the world to go by without taking much part in its stirring events. The very opposite is the case. This is doubtless partly to be accounted for by the fact that from the very earliest times the lands of the areas were alternatively in the hands of and the gift of the Crown, or in the possession of important monastic houses, the latter at least as early as A.D. 936, and again at a number of dates in the succeeding centuries. There would be, therefore, a great going to and fro between the seats of Government and the palaces of priest prelates on the one hand, and the great houses of the area on the other. There are, also, the factors which lead to the heads of the grand houses of their day taking an active part in the Wars of the Roses and Jacobite risings, to which reference has already been made, and which ultimately led a good many of them to London for trial, imprisonment, banishment or fine, and a few to Tower Hill. The history of the area is thus a very fascinating study.

It has been said more than once that all history is merely a record of a country's sorrows. That of our area is no exception. Invasion by foe and the elements, rapine, loot, earthquake, famine, pestilence, unfortunate religious and political partizanship, have all played their parts to an equal and even intensified extent, and have helped to mould the physical and political conditions which we find to-day. To enter into a description of them all and of their results would be beyond the scope of this article.

There are two other matters especially germane to our subject. Reference to archeological or historical maps show the area dotted all over with ancient crosses and their sites or remains to an extraordinary degree. All those shown are very ancient, though none would appear to approach the age of the Runic crosses to be seen in surrounding districts. Taylor, in his 'Ancient Crosses and Holy Wells of Lancashire,' gives a list of no less than 59 crosses, or remains of crosses in the Hundred of Amounderness. The following are a few :—

Bispham Churchyard Cross.  
 Bradshaw Cross, Street.  
 Buck's Cross, Holleth.  
 Breck Cross, Poulton.  
 Brunahill Cross, Garstang.  
 Cabus Cross, Cabus.  
 Car House Cross, Garstang.  
 Cathouse Cross, Garstang.  
 Catterall House Cross, Catterall.  
 Charnock House Cross, Catterall.  
 Combelaw Cross, Staynall.  
 Cook Green Cross, Forton.  
 Crawley's Cross, Stake Pool.  
 Cross Hill Cross, Scorton.  
 Fox Lane Ends Cross, Wrea Green.  
 Forton Hall Cross, Forton.

Garstang Market Cross.  
 Garstang-Churchtown Church-  
 yard Cross.  
 Garstang-Churchtown Village  
 Cross.  
 Grizedale Cross, Grizedale Reser-  
 voir.  
 Hag Wood Cross, Garstang Bye-  
 pass.  
 Hall Cross, Kirkham.  
 Higher House Cross, Kirkham.  
 Kirkham Market Cross.  
 Langtrees Cross, Claughton.  
 Laurence's Cross, Stalmine.  
 Lund Cross, Clifton.  
 Lytham Churchyard Cross.



Moorhead Cross, Forton.  
 Potter Breck Cross, Bay Horse.  
 Poulton Market Cross.  
 Ringing Hill Cross, Garstang  
 Station.

Shepherd Hill Cross, Claughton.  
 Sturzaker Cross, Garstang Station.  
 Whittingham's Cross, Barnacre.

This brings up an important point. The vast majority of those which remain, being either wayside crosses or landmarks, lie in hedgerows where they are liable to be removed or even destroyed by anyone who finds them to be in the way of his operations or inconvenient for his business, and unless they are scheduled under a statutory town-planning scheme, it may not be long, in these days of rapid change and development, before few are left, and even those few so removed from their original site as to be of little value as marking their ancient station and purpose. None within this area have so far been scheduled under the Ancient Monuments Consolidation and Amendment Act, 1913, as amended by the Ancient Monuments Act, 1931, and in view of the magnitude of the task before the Ancient Monuments Board and the Office of Works, whose list already includes more than 3,000 monuments, it would seem unlikely that the ancient cross remains, mostly boulders slotted for a cross, would be considered important enough to receive priority over larger monuments of greater intrinsic and national interest.

Action such as I have suggested under a statutory town-planning scheme would seem the only means available for insuring their preservation, or, where this is really impossible, provision in such a scheme that they shall not be disturbed until proper and sufficient records have been taken under expert supervision, normally that of the local representative of the Ancient Monuments Board.

In assessing the value of any individual cross or its remains, it is important to have a clear understanding of its purpose, which in some cases may make the position of more importance than the remains themselves, while in others the reverse may be the case. Not all of them had, as might be supposed, a religious origin, though in some cases it is evident that those originally put up as landmarks and otherwise have, in the course of time, become objects of veneration. In the proceedings of the Lancashire and Cheshire Antiquarian Society for 1898 such crosses are divided into nine classes, as follows :—

- |  |                                 |
|--|---------------------------------|
| 1. Preaching crosses.                    | 6. The cross at cross roads.    |
| 2. Churchyard crosses.                   | 7. Crosses at holy wells.       |
| 3. Roadside or weeping crosses.          | 8. Sanctuary crosses.           |
| 4. Market crosses.                       | 9. Crosses as guide posts,      |
| 5. Boundary crosses and meare<br>stones. | memorial and murder<br>crosses. |

The first in the list, preaching crosses, are probably the oldest of all. Generally, they will be found to be synonymous with the churchyard crosses. At places where there was no church, a cross was erected to mark the preaching place. The church being subsequently built there, the two are found in close juxtaposition, as at Garstang, Lytham, Bispham and elsewhere. Almost invariably the cross is to be found at the south side of the chancel, if in its original position. It might seem that in such surroundings its preservation was assured, and no other action, whether under a statutory planning scheme



or otherwise, would be necessary. This is by no means the case. For instance, in Garstang Churchtown churchyard, the heavy base of the old cross has been torn from its traditional site and used as part of the base of a new and modern cross to the east of the chancel, only a portion of the old shaft being left to mark its original and traditional position.

The term 'weeping cross' may not be familiar. Before the days of the hearse, when the dead were necessarily borne by the mourners all the way to the church, funeral parties used to stop at places *en route* to rest the bearers. These established places were marked by crosses, and Fishwick in his History of Garstang, says :

'There are people still living who remember seeing Roman Catholic funeral processions pause and rest the coffin at the remains of the cross near Cross House in Kirkham.'

Market crosses may in many instances have begun as preaching crosses, though later on they attained a more secular use. The extent was remarkable to which they served to sanctify a bargain, or give authority to a proclamation, and even a highway robber or other cut-throat would leave immune a lonely traveller who could reach a cross before being overtaken.

Boundary crosses had primarily a secular purpose. Indeed, some of those marked on the map, and the remains of which still exist, may, quite conceivably never have been crosses at all, but merely upright, armless posts. That at Greenlands, now standing uprooted at the side of the Garstang bye-pass, has every appearance of being of that class, and its removal, however necessary, is thus the more to be deplored as rendering any reference to it unintelligible which may occur in any ancient monastic or other records. In other cases the boundary stone did take the form of a cross, especially when it marked the confines of or other points on the lands of Cockersands Abbey. Crawley's Cross, at a sharp angle in the northern boundary of the area east of Stake Pool, and thus on the boundary of the Hundreds of Lonsdale and Amounderness, partakes of the latter character. Doubtless this form of landmark was definitely more inviolable, especially in superstitious days.

The existence of three holy wells which were at one time within this area has been traced as follows :—

1. The Fairy Well, Preesall.
2. St. Ellin's Well, Bleasdale.
3. The Holy Well, Bispham.

None of these remains. The site of that just north of Preesall Hill is marked on the Archeological Map, and the one at Bispham, though in existence in 1867, has since been filled up. None had crosses so far as can be traced ; if they had, they have disappeared.

## III.

## THE FYLDE

THE Fylde has been so named as a distinctive region or *pays* in the French sense from at least the late thirteenth century. Camden (1590) says that the ancient hundred of Amounderness 'has rich pastures especially on the sea side which is partly champain, whence part of it seems to be called the File, *q.d.* the Field.' Later forms are Field, File, Filde and Fylde, the last accepted as the modern name of the rural district. The etymology of the name may not be that suggested by Camden.

It is popularly assumed to include the plain between the Ribble Estuary and Morecambe Bay west of the Preston-Lancaster main road, but originally it was bounded north of the river Wyre by Pilling, Winmarleigh and Cockerham mosses, forming the Over-Wyre district.

Its eastern boundary was probably that of the modern rural district about five or six miles west of the main road mentioned. Within that area occur all the windmills for corn-milling, for which the Fylde was famous, and most of the villages with the appellation *le-Fylde*, to distinguish them from villages of the same name in other parts of the county.

On the western side of the line lies the village of Field Plumpton, on the eastern that of Wood Plumpton.

Not until the nineteenth century did the needs of the industrial north bring into existence the belt of littoral resorts which to-day make the sharp contrast between the urbanised coast and the still essentially rural interior. Of these Blackpool in the centre and Lytham St. Annes in the south-west corner are the largest. In the north-west the port of Fleetwood, at the mouth of the Wyre, has developed great fishing activities and has also acquired a residential character.

## GEOLOGY AND PHYSICAL FEATURES

BY

R. KAY GRESSWELL, M.A., F.R.G.S.

THE underlying Triassic Keuper Marl, giving place along a N.-S. fault-line to Bunter eastwards and probably some Permian in the north-east, is hidden everywhere by thick glacial drift with superimposed peat, alluvium and blown sand. The hummocky surface forms 50-100 feet cliffs between Blackpool and Bispham, falls eastward to a line of low Carrs continuing southwards the line of the lower Wyre, and then rises eastwards to somewhat over 100 feet.



The river Wyre is formed by the union of streams from Tarnbrook and Marsham Fells, and then flows south to Garstang, south-west to Poulton, and finally north to Fleetwood.

The Pleistocene glacial drift, laid down on a denuded platform, includes Lower and Upper Boulder Clays sometimes distinguishable because Middle Sands and Gravels occur between. The basic study is by De Rance, who found at Eagberg Brow, Norbreck, a 30 feet high dome of Boulder Clay covered by silt-laminic (3 inches to 5 inches), green and brown or purple, and containing large erratics. The erratics near the top are smaller and layered. The Middle Sands and Gravels are variable, with 2 feet to 4 feet layers of sand and gravel alternating for some 14 feet and a cover of 16 feet of sand ; they show current bedding. These Middle Sands were laid down in waters held up in front of the earlier ice-sheet as it retreated, and their undisturbed state shows that they were frozen when the ice bringing the Upper Boulder Clay advanced over them.

The Middle Sands and Gravel underlie almost the whole of the Upper Boulder Clay of the Fylde, but at several places the capping of the latter has been removed, and the Middle Sands form the present surface. The largest outcrop in the Fylde has an area of about half a square mile, and is midway between Inskip and Elswick, two miles south-south-west of St. Michaels. Two-and-a-half miles west of this, there is another about half the size by the hamlet of Thistleton. The western portion of Kirkham is on Middle Sand, and there are several other very small scattered outcrops.

In the spring of 1936, owing to imperfections in the grass cover just south of Bispham, the Middle Sands could be seen at the top of the cliff, overlying the Lower Boulder Clay. North of Norbreck, the cliff becomes fairly low, and is at present untended in its upper portion, and consists of a steep slope of Boulder Clay almost entirely obscured by grass.

The Upper Boulder Clay is fairly constant in character, although collections of erratics differ even when made in much the same locality. There seem usually to be from 40 to 50 per cent. of Lake District volcanic rocks, from 40 to 60 per cent. of Silurian grits, from 0 to 20 per cent. of Carboniferous limestone, some Coal Measure sandstones, and occasional Permian and other rocks.

The following shells were recorded by De Rance<sup>1</sup> as having been found in the Blackpool district, the nomenclature having been brought up to date<sup>2</sup>. Where the modern name differs from that given by De Rance, the latter's is placed in brackets after it.

L = found in Lower Boulder Clay.

M = found in Middle Sands and Gravel.

U = found in Upper Boulder Clay.

— M — *Patella vulgata* L.

— M — *Gibbula cineraria* (L.). (*Trochus cinerarius*, Linn.)

— M — *Littorina littorea* (L.).

<sup>1</sup> De Rance, 'Superficial geology of . . . south-west Lancashire,' *Mem. Geol. Survey*, 1877, p.p. 128-130.

<sup>2</sup> For revising this list in accordance with the arrangement and nomenclature as in Winckworth's 1932 list (*Journ. Conch.*, vol. 19, pp. 217-252), I am indebted to Miss N. Fisher, of Liverpool Museum.



- M U *Littorina saxatilis* (Olivi). (*Littorina rudis*, Don.)
- M — *Littorina littoralis* (L.). (*Littorina obtusata*, Linn.)
- L M U *Turritella communis* Risso. (*Turritella terebra*, Linn.)
- M — *Aporrhais pespelicani quadrifidus* da C. (*Aporrhais pespelicani*, Linn.)
- M — *Natica catena* (da C.).
- M — *Trivia* sp. (*Cypraea Europaea*, Mont.)
- M — *Trophon clathratus* L.
- M U *Nucella lapillus* (L.). (*Purpura lapillus*, Linn.)
- L M — *Ocenebra erinacea* (L.). (*Murex erinaceus*, Linn.)
- M — *Neptunea antiqua* (L.). (*Fusus antiquus*, Linn.)
- L M — *Buccinum undatum* L.
- L M — *Nassarius reticulatus* (L.). (*Nassa reticulata*, Linn.)
- L — — *Nassarius incrassatus* (Strom). (*Nassa incrassata*, Müller)
- M — *Lora turricula* (Mont.). (*Pleurotoma turricula*, Mont.)
- M — *Lora rufa* (Mont.). (*Pleurotoma rufa*, Mont.)
- M — *Lora pleurotomaria* (Couth.). (*Pleurotoma pyramidalis*, Strom)
- M — *Mangelia nebula* (Mont.). (*Pleurotoma nebula*, Mont.)
- L — U *Dentalium entalis* L.
- M — *Nucula* sp.
- L — — *Mytilus edulis* L.
- L M U *Ostrea edulis* L.
- — U *Chlamys opercularis* (L.). (*Pecten opercularis*, Linn.)
- M — *Astarte sulcata* (da C.).
- M — *Cyprina islandica* (L.).
- M — *Cardium aculeatum* L.
- — U *Cardium echinatum* L.
- — U *Cardium tuberculatum* L.
- L M U *Cardium edule* L.
- M U *Callista chione* (L.). (*Venus chione*, Linn.)
- M U *Macoma balthica* (L.). (*Tellina Balthica*, Linn.)
- L M U *Gari fervensis* (Gm.). (*Psammobia Ferröensis*, Chemn.)
- M — *Mya truncata* L.
- L — — *Hiatella gallicana* (Lam.). (*Saxicava rugosa*, Linn.)
- L — U *Zirfaea crispata* (L.). (*Pholas crispata*, Linn.)

All these are salt-water species, and only five are unknown on the Lancashire coasts to-day.

After the deposition of the Upper Boulder Clay, streams washed shingle out of the clay and caused it to collect in several small areas, notably at Preesall, from which the deposit has derived its name of Preesall shingle, and several small patches west and south-west of Garstang.

As the surface of the Upper Boulder Clay was a surface of deposition, not of erosion, there are in its surface numerous swamp hollows without outlet. They are covered with peat deposits, often thick, which also occupy several other large ill-drained areas, such as Pilling and its associated mosses.

The present surface of the peninsula west of the Wyre, between that river and the coast, north of an irregular west-east line about a mile north of Norbreck, now consists of tidal alluvium, as also does the area between the

Pilling and Cockerham mosses and the coast. Much of the valley of the Wyre and its tributary streams is river alluvium. An especially wide tract occurs just east of St. Michaels.

Estuarine alluvium occupies a large area on the north bank of the Ribble, east of Freckleton, and forms the area known as Freckleton Marsh. This is now embanked and drained, and is crossed by the main road from Preston to Blackpool *via* Lytham St. Annes. Outside the embankments there are extensive salt-marshes and mud-flats, and on the south bank of the river much land has been reclaimed by first encouraging the marshes to increase their extent by planting 'saltings,' consisting of sods of marsh grass laid about two yards apart on the sand or mud. These sods spread and join up with one another in a very few years. They are covered by the sea at every full tide, and during the slack the mud, which has been brought down by the Ribble, and which is in suspension in the water, is deposited and is held by the grass during the subsequent ebb. Thus the level of the marsh is raised by the deposition of an extremely thin, leaf-like layer of alluvium at each tide. When the area is raised sufficiently, it is embanked, and fresh saltings are often planted on the seaward side of the new coastline.

*Coastline.* Eastwards of the mouth of the river Wyre, Pilling and Cockerham salt marshes border the beach, and are partly covered during each full tide. Since the coast here faces north, and the dominant wind and most gales are from the west, it does not face the full strength of the largest waves.

From Fleetwood the coast continues to face northwards for over a mile and a half from the mouth of the Wyre. Rossall Point is then reached, and from here to South Shore, Blackpool, the coast faces due west. Observations made at the numerous groyne between Fleetwood and Blackpool show that there is a fairly powerful longshore drifting of beach material northwards. North Wharf, a bank which extends northward of the Fleetwood to Rossall Point coastline for a distance of two miles, may probably be explained by this northerly drift's failing to round Rossall Point, and continuing northward until checked by the tidal stream of the river Lune.

From Fleetwood to near Cleveleys there is a very large amount of shingle on the foreshore, and on the bend of Rossall Point there are several examples of shingle ridges, continuing northwards although the land falls away eastwards behind them.

From Cleveleys to North Shore the shingle gradually decreases in amount, until at North Shore there is only sufficient to form a triangular patch on the southward side of each groyne. From North Shore to South Shore, Blackpool, there is no shingle, the beach consisting entirely of quartz sand.

Sea walls protect the whole 12 miles of coast from Fleetwood to South Shore, Blackpool. A low alluvial coast stretches from Fleetwood to just south of Cleveleys, where peat outcrops on the foreshore. Then cliffs of Boulder Clay gradually rise to a maximim of 100 feet at North Shore, Blackpool, decreasing again and near the Tower giving place (although hidden by the sea wall) to low cliffs of blown sand, which forms the coastline to Freckleton Marsh beyond Lytham.

From the end of the Promenade at South Shore to Freckleton Marsh, there is a variable band of shingle on the backshore, the foreshore consisting

of sand as elsewhere. From South Shore to St. Annes, the only portion of the coastline still unprotected, dunes of blown sand are covered principally with starr grass (*Psamma arenaria*, Beauv.). These dunes are in need of protection from wind erosion and holiday-makers.

From St. Annes as far as Lytham, sea walls again form the coastline ; beyond this to Preston salt marsh reigns again.

#### IV.

## PHYTOGEOGRAPHY

BY

MARGARET DUNLOP.

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THE utilisation of the Fylde for food production and recreation has been carried so far that opportunities for natural vegetation have been much reduced, and most former peat bogs are identifiable only by their flatness, the high organic content of their soil, and the regularity of their field divisions.

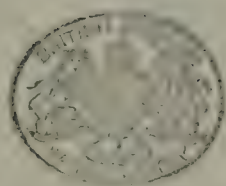
The resultant vegetation is rich with a tendency to rankness, resulting from heavy manuring, and, inland, sluggish drainage. There is not the slower and steadier growth associated with the drier soils of the Midlands or Southern England, where there is, in addition, a longer ripening period. Dense hedgerows above wide alga-filled ditches along the lanes and masses of *Funaria* among grazed turf, also testify to this.

Only in one or two centres is the vegetation a direct reflection of topographic conditions. South-west of Winmarleigh (Sheet 24, H 12),<sup>1</sup> at distances of one mile and one-and-a-half miles from the village, are two patches of woodland, largely coniferous timber and elm, founded on two deposits of Preesall shingle, and quite distinct from the former peat bog surrounding them. Thistleton is largely an area of woodland, to some extent planted on sands and gravels. There have been mosses all around the village in former times. As at Winmarleigh, many houses date from the early eighteenth century, *i.e.*, before the main reclamation, indicating early recognition of the value of sands and gravels in mainly Boulder Clay country. Cockerham, at the north-eastern extremity of our region, is above the marshes, but it is on the solid, the main road from the west entering the village through a small cutting.

There are no extensive woodlands, and no trees of any antiquity to record. The largest in natural woodland are probably those by the brook near Kirkham Railway Station. Very often the tree belts are narrow, and are preserved only as wind-breaks. Nevertheless, in cultivated areas the relatively undisturbed surface which the woods provide continues to support a few heaths and, less

<sup>1</sup> The 1 in. (Popular Edition) Ordnance Survey Maps.





THE MAJOR PHYTOGEOGRAPHIC REGIONS OF THE FYLDE.

THE MAJOR PHYTOGEOGRAPHIC REGIONS OF THE FYLDE



frequently, bog plants. The undergrowth is never very dense, as rabbits are frequent. Elder is a common constituent of it. *Acer* is common where the Middle Sands predominate, e.g., at Plumpton (Sheet 29, C. 9), but it is replaced largely by *Ulmus* on the clays. Conifers are rare outside plantations. The flatness means severe exposure for some distance inland, and trees are much slower in both seasonal and annual development than is normal for Northern England. Willows (*Salix pentandra*, *S. alba*, *S. viminalis*, *S. Caprea*, *S. aurita*) are very common along ditches (*S. repens* was formerly ubiquitous on the dunes), but the sluggish streams are rarely wooded, by reason of the embankments piled up from year to year in clearing them.

### THE MAIN PHYTOGEOGRAPHICAL DIVISIONS.

#### AREAS I. AND II.

Most of the former bog north of the Wyre is now pasture and arable land, and there is no great development of poultry farming as in the Fylde proper. The woods are few. The former extent of the woodland may be judged roughly from sections along field margins, although no pollen analyses are available. Nevertheless, from these sections it is obvious that the trees of the 'Mixed Oak Period' were well represented.

The West Lancashire peats have very little commercial value. Mining into the Trias for salt comparable in age to that of Cheshire takes place below the superficial deposits around Preesall. (Sheet 24, G. 10.)

In the coastal areas the mudflats, stretching from the mouth of the Cocker to a point about a mile west of Pilling, are distinct from the dry, sandy tract with shingle, partly enclosed behind a sea wall, which reaches westward from this point to the eastern side of the mouth of the Wyre at Knott End. (Areas I. and II. respectively on the map.) Along the coast in this last division is an area of blown sand smaller than the similar belt around St. Annes; inland, sand gives place to alluvium.

The marsh is wider in extent in Cockerham Moss than in Pilling Moss. There are fewer streams, and the salt marsh surface is firmer. The improved drainage brings in *Ulex* and *Urtica* in profusion. Near the sea the ubiquitous *Ranunculus ficaria* (Lesser Celandine) and more common Umbellifers are found in all but the tidal ditches.

Writing in 1907 Wheldon and Wilson gave the following rarer species for the eastern mud flats<sup>1</sup> :—

(English names have been added where practicable.)

|                               |      |      |                             |
|-------------------------------|------|------|-----------------------------|
| <i>Cochlearia officinalis</i> | .... | .... | Scurvy Grass.               |
| <i>Cochlearia Anglica</i>     | .... | .... | English Grass.              |
| <i>Apium graveolens</i>       | .... | .... | Celery.                     |
| <i>Oenanthe Lachenalii</i>    | .... | .... | Cylindrical Water Dropwort. |
| <i>Aster Tripolium</i> ....   | .... | .... | Sea Aster.                  |
| <i>Artemisia maritima</i>     | .... | .... | Marine Wormwood.            |
| <i>Statice Armeria</i> ....   | .... | .... | Plantain Thrift.            |
| <i>Glaux maritima</i> ....    | .... | .... | Sea Milkwort.               |

<sup>1</sup> Wheldon, J. A., and Wilson, A., *The Flora of West Lancashire*, 1907.



|                             |      |      |                       |
|-----------------------------|------|------|-----------------------|
| <i>Plantago maritima</i>    | .... | .... | Sea Plantain.         |
| <i>Atriplex littoralis</i>  | .... | .... | Sea Arrow Grass.      |
| <i>Salicornia europea</i>   | .... | .... | Marsh Samphire.       |
| <i>Suaeda maritima</i>      | .... | .... | Herbaceous Sea Blite. |
| <i>Juncus maritimus</i>     | .... | .... | Sea Rush.             |
| <i>Juncus Gerardi</i>       | .... | .... | Round-Fruited Rush.   |
| <i>Triglochin maritimum</i> | .... | .... | Sea Arrow Grass.      |
| <i>Scirpus maritimus</i>    | .... | .... | Sea Scirpus.          |
| <i>Carex distans</i>        | .... | .... | Distant Sedge.        |
| <i>Sclerochloa maritima</i> | .... | .... | Sea Sclerochloa.      |
| <i>Lepturus filiformis</i>  | .... | .... | Curved Lepturus.      |

For the western, drier, division, the following are characteristic :—

|                                 |      |      |                         |
|---------------------------------|------|------|-------------------------|
| <i>Cakile maritima</i>          | .... | .... | Sea Rocket.             |
| <i>Trifolium arvense</i>        | .... | .... | Hare's Foot Clover.     |
| <i>Trifolium fragiferum</i>     | .... | .... | Strawberry Clover.      |
| <i>Eryngium maritimum</i>       | .... | .... | Sea Holly.              |
| <i>Chaerophyllum anthriscus</i> | .... | .... | Burr Chervil.           |
| <i>Limonium vulgare</i>         | .... | .... | Sea Lavender.           |
| <i>Limonium binervosum</i>      | .... | .... | Bi-nerved Sea Lavender. |
| <i>Limonium humile</i>          | .... | .... |                         |
| <i>Obione portulacoides</i>     | .... | .... | Sea Purslane.           |
| <i>Atriplex littoralis</i>      | .... | .... | Maritime Orache.        |
| <i>Atriplex Babingtonii</i>     | .... | .... |                         |
| <i>Atriplex laciniata</i>       | .... | .... | Frosted Orache.         |
| <i>Salsola Kali</i>             | .... | .... | Saltwort.               |
| <i>Polygonum Roberti</i>        | .... | .... |                         |
| <i>Carex arenaria</i>           | .... | .... | Sand Sedge.             |
| <i>Triticum junceum</i>         | .... | .... | Quitch.                 |

### AREA III.

A small tract of country along the river Cocker below Cockerham is worthy of some mention. It consists of low, flat alluvium drained by ditches, and yields the following :—

|                                 |      |      |                     |
|---------------------------------|------|------|---------------------|
| <i>Ranunculus Baudotii</i>      | .... | .... |                     |
| <i>Oenanthe fistulosa</i>       | .... | .... | Water Dropwort.     |
| <i>Bidens cernua</i>            | .... | .... | Burr Marigold.      |
| <i>Hottonia palustris</i>       | .... | .... | Water Violet.       |
| <i>Samolus Valerandi</i>        | .... | .... | Brookweed.          |
| <i>Callitriche autumnalis</i>   | .... | .... | Autumn Starwort.    |
| <i>Hydrocharis morsus-Ranae</i> | .... | .... | Frogbit.            |
| <i>Carex disticha</i>           | .... | .... | Slender Sand Sedge. |

Clean-cut ditches along the Cocker below Cockerham are rapidly clothed with lichens, whilst the surface of the water soon becomes a mass of algal filaments. Algae are very common throughout the sluggish Fylde ditches, and benefit by the drainage of the heavily-manured fields. *Potamogeton natans* (Broad Pondweed) is common throughout the Fylde ditches and numerous ponds.

## AREA IV.

The more typical undrained portions of Cockerham Moss, the average elevation of which is 30 feet, are not unlike the great red bogs overlying the Irish glacial material. The northern side, approximately one mile from the sea, is more attractive to the botanist, much of it being pure sphagnum bog, quaking underfoot as in Ireland. Here one finds :—

|                              |      |      |                         |
|------------------------------|------|------|-------------------------|
| <i>Drosera rotundifolia</i>  | .... | .... | Round-leaved Sundew.    |
| <i>Drosera anglica</i>       | .... | .... | English Sundew.         |
| <i>Vaccinium oxycoccus</i>   | .... | .... | Cranberry.              |
| <i>Andromeda polyfolia</i>   | .... | .... | Marsh Andromeda.        |
| <i>Erica tetralix</i>        | .... | .... | Cross-leaved Heath.     |
| <i>Narthecium ossifragum</i> | .... | .... | Bog Asphodel.           |
| <i>Eriophorum vaginatum</i>  | .... | .... | Sheathing Cotton Grass. |
| <i>Rhynchospora alba</i>     | .... | .... | White Beak Sedge.       |
| <i>Carex canescens</i>       | .... | .... | Whitish Sedge.          |
| <i>Carex limosa</i>          | .... | .... | Mud Sedge.              |
| <i>Molinia coerulea</i>      | .... | .... | Purple Molinia.         |

And where the surface is drier and more uneven :—

|                                |      |      |                      |
|--------------------------------|------|------|----------------------|
| <i>Rubus plicatus</i>          | .... | .... | Plicate Bramble.     |
| <i>Calluna vulgaris</i>        | .... | .... | Ling.                |
| <i>Melampyrum pratense</i>     | .... | .... | Crested Cow Wheat.   |
| <i>Betula pubescens</i>        | .... | .... | Common Birch.        |
| <i>Salix cinerea</i>           | .... | .... | Grey Sallow.         |
| <i>Myrica gale</i>             | .... | .... | Sweet Gale.          |
| <i>Empetrum nigrum</i>         | .... | .... | Crowberry.           |
| <i>Orchis latifolia</i>        | .... | .... | Marsh Orchis.        |
| <i>Juncus bulbosus</i>         | .... | .... | Bulbous Buttercup.   |
| <i>Eriophorum polystachion</i> | .... | .... | Common Cotton Grass. |
| <i>Lastrea spinulosa</i>       | .... | .... | Broad Shield Fern.   |

The middle Wyre floods, and has artificially-strengthened banks, but the cliffs of the lower course are natural. At Shard Bridge the Upper Drift of yellow-brown clay forms the 35 feet northern bank, and supports small plantations ; the south bank is formed by Upper Boulder Clay. A tidal flat below the cliffs supports the following :—

|                             |      |      |                         |
|-----------------------------|------|------|-------------------------|
| <i>Cochlearia anglica</i>   | .... | .... | English Scurvy Grass.   |
| <i>Brassica monensis</i>    | .... | .... | Isle of Man Cabbage.    |
| <i>Aster Tripolium</i>      | .... | .... | Sea Aster.              |
| <i>Tanacetum vulgare</i>    | .... | .... | Tansy.                  |
| <i>Artemisia maritima</i>   | .... | .... | Sea Artemisia.          |
| <i>Limonium vulgare</i>     | .... | .... | Sea Lavender.           |
| <i>Limonium humile</i>      | .... | .... | .                       |
| <i>Limonium binervosum</i>  | .... | .... | Bi-nerved Sea Lavender. |
| <i>Atriplex littoralis</i>  | .... | .... | Maritime Orache.        |
| <i>Atriplex deltoidea</i>   | .... | .... |                         |
| <i>Atriplex Babingtonii</i> | .... | .... |                         |
| <i>Atriplex laciniata</i>   | .... | .... | Frosted Orache.         |
| <i>Obione portulacoides</i> | .... | .... | Sea Purslane.           |

|                                      |      |      |                      |
|--------------------------------------|------|------|----------------------|
| <i>Suaeda maritima</i>               | .... | .... | Herbaceous Seablite. |
| <i>Triglochin maritimum</i>          | .... | .... | Sea Arrow Grass.     |
| <i>Carex distans</i>                 | .... | .... | Distant Sedge.       |
| <i>Carex extensa</i>                 | .... | .... | Long-bracted Sedge.  |
| <i>Triticum pungens v. littorale</i> | .... | .... | Sea Wheat.           |
| <i>Pottia littoralis</i>             | .... | .... | Shore Pottia.        |
| <i>Tortula aloides</i>               |      |      |                      |

## AREA V.

Building and with it destruction of the sand-dune belt is progressing rapidly. Utilisation for golf links has also increased. 'It is painful to think how many of these plants have now gone, and none of the old marshy ground remains in its original condition. Where not already built upon it is "improved" and drained, and given over to crowds of excursionists, or converted into golf links. Here amongst a silvery carpet of dwarf willow (*Salix repens v. argentea*) grew a rich profusion of *Epipactis longifolia* (Marsh Helleborine), *Orchis incarnata* (Narrow-leaved Marsh Orchid), *Pyrola rotundifolia v. arenaria* (Small-leaved Larger Wintergreen), *Parnassia palustris* (Grass of Parnassus), and the curious *Monotropa hypopitys* (Yellow Bird's Nest). In July the damper spots were pink with *Anagallis tenella* (Bog Pimpernel), and with it flourished *Carex Oederi* (Short-beaked Yellow Sedge), *Selaginella selaginoides* (Lesser Clubmoss), *Equisetum variegatum*, *Bryum Warneum*, *Bryum lacustre*, *Hypnum Wilsoni*, *v. hamatum*, *Hypnum lycopodioides*, and other interesting species. On drier ground about the foot of some of the dunes grew *Convolvulus soldanella* (Sea Bindweed), *Brassica monensis* (Isle of Man Cabbage), and *Vicia lathyroides* (Spring Vetch), whilst in many parts the sand was gay with bright patches of rest harrow, yellow bedstraw, skullcap, and centaury, of which latter three species were abundant.' <sup>1</sup>

The following list is representative of present and former flowering plants around St. Annes, where the curve of the coast gives this region advantage of aspect over e.g., the Rossall dunes, and where the former practice of poultry farming, proximity to the Ribble, and greater mass of dunes to the south of the estuary, have made introduced species more common than elsewhere.

The reflection of an excess of silica and deficiency of humus and free water is well shown in the occurrence of many xerophytes and highly modified species. This deficiency of moisture and of humus greatly limits the cryptogams, and above all the fungi.

|  |      |      |                               |
|--|------|------|-------------------------------|
| <i>Thalictrum dunense</i>                | .... | .... | Sand Meadow Rue. <sup>1</sup> |
| <i>Ranunculus Baudotii</i>               |      |      |                               |
| <i>Cochlearia danica</i>                 | .... | .... | Danish Scurvy Grass.          |
| <i>Sisymbrium Thalianum</i>              | .... | .... | Thale Cress.                  |
| <i>Brassica monensis</i>                 | .... | .... | Isle of Man Cabbage.          |
| <i>Diplotaxis muralis v. Babingtonii</i> |      |      | Stinkweed.                    |
| <i>Callile maritima</i>                  | .... | .... | Sea Rocket.                   |
| <i>Reseda lutea</i>                      | .... | .... | Cut-leaved Mignonette.        |
| <i>Viola canina</i>                      | .... | .... | Dog Violet.                   |
| <i>Viola Curtisii</i>                    | .... | .... | Sand Pansy.                   |

<sup>1</sup> Wheldon and Wilson, *Op. cit.*



|   |      |      |                                  |
|---|------|------|----------------------------------|
| <i>Viola Pesneausii</i>                       |      |      |                                  |
| <i>Polygala oxyptera</i>                      | .... | .... | Linear Milkwort.                 |
| <i>Saponaria officinalis</i>                  | .... | .... | Soapwort.                        |
| <i>Silene maritima</i>                        | .... | .... | Sea Bladder Campion.             |
| <i>Cerastium tetrandrum</i>                   | .... | .... | Branched Mouse-Ear Chickweed.    |
| <i>Cerastium semidecandrum</i>                | .... | .... | Slender Mouse-Ear Chickweed.     |
| <i>Arenaria Lloydii</i>                       | .... | .... | Lloyd's Sandwort.                |
| <i>Trifolium arvense</i>                      | .... | .... | Hare's Foot Clover.              |
| <i>Trifolium suffocatum</i>                   | .... | .... | Suffocated Clover.               |
| <i>Trifolium fragiferum</i>                   | .... | .... | Strawberry Clover.               |
| <i>Vicia lathyroides</i>                      | .... | .... | Spring Vetch.                    |
| <i>Rubus caesius</i>                          | .... | .... | Dewberry.                        |
| <i>Rosa spinosissima</i>                      | .... | .... | Burnet.                          |
| <i>Parnassia palustris</i>                    | .... | .... | Grass of Parnassus.              |
| <i>Eryngium maritimum</i>                     | .... | .... | Sea Holly.                       |
| <i>Erigeron acris</i>                         | .... | .... | Fleabane.                        |
| <i>Inula vulgaris</i>                         | .... | .... | Small Fleabane.                  |
| <i>Carlina vulgaris</i>                       | .... | .... | Carlina Thistle.                 |
| <i>Cichorium Intybus</i>                      | .... | .... | Chicory.                         |
| <i>Hieracium umbellatum</i> v.                |      |      |                                  |
| <i>coronopifolium</i>                         | .... | .... | Umbellate Hawkweed.              |
| <i>Taraxacum officinale</i> v.                |      |      |                                  |
| <i>erythrospermum</i>                         | .... | .... | Large-bracted Dandelion.         |
| <i>Pyrola rotundifolia</i> v. <i>arenaria</i> | .... | .... | Small-leaved Larger Wintergreen. |
| <i>Monotropa Hypopitius</i>                   | .... | .... | Yellow Bird's Nest.              |
| <i>Glaux maritima</i>                         | .... | .... | Sea Milkwort.                    |
| <i>Anagallis tenella</i>                      | .... | .... | Bog Pimpernel.                   |
| <i>Samolus Valerandi</i>                      | .... | .... | Brookweed.                       |
| <i>Erythraea vulgare</i>                      | .... | .... | Common Centaury.                 |
| <i>Erythraea pulchella</i>                    | .... | .... | Annual Centaury.                 |
| <i>Gentiana baltica</i>                       | .... | .... | Baltic Gentian.                  |
| <i>Cynoglossum officinale</i>                 | .... | .... | Common Hound's Tongue.           |
| <i>Myosotis collina</i>                       | .... | .... | Early Forget-me-not.             |
| <i>Echium vulgare</i>                         | .... | .... | Viper's Bulgloss.                |
| <i>Convolvulus Soldanella</i>                 | .... | .... | Sea Bindweed.                    |
| <i>Cuscuta Epithymum</i>                      | .... | .... | Lesser Dodder.                   |
| <i>Lasiopera viscosa</i>                      |      |      |                                  |
| <i>Calamintha vulgare</i>                     | .... | .... | Wild Basil.                      |
| <i>Scutellaria galericulata</i>               | .... | .... | Common Skullcap.                 |
| <i>Salsola Kali</i>                           | .... | .... | Saltwort.                        |
| <i>Atriplex littoralis</i>                    | .... | .... | Narrow-leaved Orache.            |
| <i>Euphorbia Paralias</i>                     | .... | .... | Sea Spurge.                      |
| <i>Euphorbia portlandica</i>                  | .... | .... | Portland Spurge.                 |
| <i>Triglochin maritimum</i>                   | .... | .... | Sea Arrow Grass.                 |
| <i>Epipactis longifolia</i>                   | .... | .... | Narrow-leaved Helleborine.       |
| <i>Epipactis Helleborine</i>                  | .... | .... | Broad Helleborine.               |
| <i>Orchis latifolia</i>                       | .... | .... | Marsh Orchid.                    |
| <i>Eleocharis uniglumis</i>                   | .... | .... | Single-glumed Scirpus.           |
| <i>Blysmus rufus</i>                          | .... | .... | Narrow Blysmus.                  |

|  |      |                        |
|--|------|------------------------|
| <i>Carex arenaria</i> ....                     | .... | Sand Sedge.            |
| <i>Carex Oederi</i> ....                       | .... | Yellow Sedge.          |
| <i>Phlaeum arenarium</i> ....                  | .... | Sand Cat's Tail Grass. |
| <i>Festuca fasciculata</i>                     |      |                        |
| <i>Triticum junceum</i> ....                   | .... | Sand Quitch.           |
| <i>Elymus arenarius</i> ....                   | .... | Sand Elymus.           |
| <i>Equisetum variegatum</i> ....               | .... | Variegated Horsetail.  |
| <i>Selaginella selaginoides</i> ....           | .... | Lesser Clubmoss.       |
| <i>Chara vulgaris</i> v. <i>longibracteata</i> |      | Long-bracted Chara.    |
| <i>Nitella glomerata</i> ....                  | .... | Brackish Nitella.      |

The most interesting aliens are *Oenothera Lamarkiana*, the striking Evening Primrose, which still exists in great profusion on the St. Annes dunes, *Ambrosia artemisfolia* (American Wormwood), and *Sisymbrium pannonicum* (Tumbling Mustard), found elsewhere along the Fylde coast, which are also maintaining themselves.<sup>2</sup>

#### THE BUILT-UP AREA.

Rossall Point, and the dunes to the south as far as Rossall School, are more or less free of property. The northward extension of the built-up area associated with Blackpool is first met at Cleveleys, although here it does not extend far inland. One-and-a-half miles down the coast is some of the most recent evidence of the popularity of Blackpool for both seasonal and permanent residence, and to-day, as may be seen from the map, Norbreck, Bispham, Carleton (Sheet 29, B. 3), and Poulton-le-Fylde, are ever-widening groups linked by long lines of houses. Blackpool stretches due east from the Central Pier to Great Marton (Sheet 29, C. 3) and into the former bog land around Marton Mere. Market-gardening, mainly for the provision of green vegetables and spring flowers, is a big feature of this reclaimed land, and reaches southward to Blowing Sands (Sheet 29, D. 3), where large glass-houses are common.

Blackpool is stretching southward and St. Annes eastwards, but there remains a mile of untouched dune between the two, whilst between St. Annes and Fairhaven, the dunes, although backed by houses, are still in evidence; Lytham has increased relatively little. At Warton (Sheet 29, E. 6), poultry farming is a popular means of remuneration, and a phenomenon as catastrophic for the botanist as building, apart from the interesting casuals which the poultry food provides.

#### AREA VI.

Grazing land in the Marton region is very wet, with poor grass, and much rush and sedge. South of Inskip the moss has been converted into rich arable land, which formerly supported corn.

The region enclosed within lines drawn through Marton, Weeton (Sheet 29, C. 5), Singleton (Sheet 29, B. 5), and Poulton-le-Fylde, supports the following :—

|                              |      |                           |
|------------------------------|------|---------------------------|
| <i>Castalia alba</i> ....    | .... | White Water Lily.         |
| <i>Pimpinella major</i> .... | .... | Greater Burnet Saxifrage. |

<sup>2</sup> For a detailed statement see Charles Bailey, *On the Adventitious Vegetation of the Sandhills of St. Annes-on-Sea*. Memoirs and Proceedings of the Manchester Literary and Philosophical Society, 1902-3, 1907, and 1909-10.

|                                 |      |                                 |
|---------------------------------|------|---------------------------------|
| <i>Oenanthe fistulosa</i>       | .... | Water Dropwort.                 |
| <i>Bidens cernua</i>            | .... | Bur Marigold.                   |
| <i>Bidens tripartita</i> ....   | .... | Three-cleft Bur Marigold.       |
| <i>Hottonia palustris</i>       | .... | Water Violet.                   |
| <i>Typha angustifolia</i>       | .... | Lesser Reedmace.                |
| <i>Sparganium neglectum</i>     | .... | Long-beaked Branched Burr-Reed. |
| <i>Lemna gibba</i>              | .... | Gibbous Duckweed.               |
| <i>Potamogeton obtusifolius</i> | .... | Obtuse Pondweed.                |
| <i>Scirpus lacustris</i> ....   | .... | Bulrush.                        |
| <i>Glyceria aquatica</i>        | .... | Reed Poa.                       |

## AREA VII.

(The inland area around Kirkham.)

We are now left with the region east of that last dealt with. Geologically, the Kirkham neighbourhood consists of Triassic Pebble Beds, and Triassic Marl, overlain by deep deposits of glacial drift and Boulder Clay. The country around Catforth and Inskip was, together with Region VIIa., i.e., that now drained by Woodplumpton Brook, extensive bog. The species of interest are bog survivals and plants of the ditches :—

|                                 |      |                           |
|---------------------------------|------|---------------------------|
| <i>Potamogeton obtusifolius</i> | .... | Obtuse Pondweed.          |
| <i>Sparganium simplex</i>       | .... | Simple Burr-Reed.         |
| <i>Scirpus sylvaticus</i>       | .... | Wood Scirpus.             |
|                                 |      | and                       |
| <i>Thalictrum flavum</i>        | .... | Common Meadow Rue.        |
| <i>Oenanthe aquatica</i>        | .... | Water Dropwort.           |
| <i>Bidens tripartita</i> ....   | .... | Three-cleft Bur Marigold. |

Farming in this district is probably the most varied and most successful in the Fylde.

## V.

## THE PEAT MOSSES OF THE FYLDE

BY

F. WALKER.

---

THE peat mosses of the Fylde form one of the most interesting features of the physical geography of the district, and there have been frequent references to them since the mediaeval period.

At the foundation of the Lytham cell at the end of the twelfth century the position of a great moss in south-west Fylde was used in dividing land between



FitzRoger and Moreton,<sup>1</sup> while in 1271 a boundary decision in the Duchy Court mentions the same moss between Merton (Marton) and Lithum (Lytham).<sup>2</sup> Further, an act in the Coucher Book of Walley in the thirteenth century relates to disputed rights in the marsh, and grants of land to the Abbey of Cockersand during the period refer to the moss.<sup>3</sup> North of the upland of central Fylde, and west of the Wyre at Thornton, a somewhat smaller area of marsh is mentioned in an early thirteenth century grant in Frankalmoign to the Cockersand Abbey from W. de Quinequike.<sup>4</sup>

East and north of the Wyre, Garstang covered an area of rather more than 28,000 acres at Domesday; less than 1,500 acres of it were cultivated, probably because of the extent of marshy land, since Kirkham on the higher and drier water parting had 5,000 acres of cultivated land out of a total of some 30,000 acres. There are a great many references to the mosses of Preesall, Rawcliffe, Stalmine, Winmarley and Pilling in this area in the Chartulary of the Abbey of Cockersand, while Pilling is referred to as being within the forest of Wyresdale.

Even in the most economically advanced parts of England, however, no true reclamation of marsh took place before Tudor times, and in the late sixteenth century the existing peat mosses of the Fylde covered almost all the areas where peat can be shown to have existed. Saxton's map (1577) shows two very large areas of moss in this district, Pyllyn Moss to the north-east of the Wyre, and Marton Moss to the south-west; the third area of moss at Thornton is not indicated. Pyllyn Moss covers the whole of the moss area within the curve of the Wyre, which later became known separately as Pilling, Stalmine, Rawcliffe, Winmarley and Cockerham mosses. It was roughly circular in shape within the following limits:—on the south a strip of land parallel to the Wyre and about half-a-mile wide, on the north the coast, and on the east the town of Garstang; on the west it reached within a mile of the Wyre estuary.

The south and west limits of Marton Moss on Saxton's map are formed by the coast, the northern edge is marked by Marton Mere, while its landward extent is defined by the line Plumpton-Westby Hall-Lytham. Similar distributions of moss are shown on the maps of Speed (1610), Janson (1645), and Blaeu (1642), and Drayton, in his 'Polyolbion' (1613), says of the river Skippon in Fylde:—

'She in her crooked path to seaward softly glides,  
Where Pellin's mighty moss and Merton's on her sides  
Their boggy breasts outlay and Skippon down doth crawl  
To entertain this Wyre attained at her fall.'

While James, in 'Iter Lancastrense' (1676) says:—

'But greater wonders call me hence: ye deepe  
Low spongie mosses yet remembrance keep  
Of Noah's flood.'

That the mosses had long been important as pasture and for fuel is shown by the number of grants of pasture and turbary mentioned in the Chartulary

<sup>1</sup> Lytham Chartulary, quoted at length in *History of Lytham* (Chetham Society).

<sup>2</sup> *Ibid.*

<sup>3</sup> Chartulary of Cockersand Abbey (Chetham Society).

<sup>4</sup> *Ibid.*

of the Cockersand Abbey (e.g., *et pasturae totius mussae circumadjacentis*),<sup>1</sup> and later entries in the Duchy records and elsewhere in which rights of pasture and turbary are disputed (e.g., Woodplumpton, 1542-3).<sup>2</sup> Increased cutting and more constant utilisation reduced the mosses, and on Morden's map of 1700 both Pilling and Marton mosses are smaller than on earlier maps. On Moll's map of some years later Pilling moss occupies only a compact ellipse of land at a considerable distance from the Wyre on the south and the coast on the north, while Marton moss no longer continued to the coast at Lytham in the south, but ended near the present site of St. Annes.

In 1731 a scheme to improve the Marton area was agreed upon, and although by 1741 no progress had been made yet in 1780 reclamation was going ahead well.<sup>3</sup> Presumably as a result of this scheme Marton moss does not appear on Bowen's map (1767), or on that of Harrison (1789), and on the latter a road appears from Latton (near the present Blackpool) to Lytham. A much larger map by Yates and Billinge in 1786, however, shows that a considerable area of moss still remained between Higher Ballum and Moss Side, while a small patch of moss is also shown in Weeton just south of Mythorpe. On the larger and very much more accurate maps of the early nineteenth century (Smith 1808, and Greenwood 1818), these patches of moss still remain, though on Hennet's map of 1828-29 the Weeton moss is not marked. In 1810 Marton moss is mentioned by Britton and Brayley<sup>4</sup> as one of the principal mosses of Lancashire and the digging of moss at Morton is mentioned in Butterworth's statistical hand-book (1841).

The 1 inch O.S. map (1842) shows reclamation completed, since no moss is marked in the south-west of the Fylde, though Lytham Moss and Marton Moss are both named, and in the same district the place names, Moss Hall, Moss House, Moss Edge, West Moss, Brown Moss Edge, Lower Brown Moss, on the map indicate former conditions. The moss of St. Michaels, between that town and Sowerby, and the moss to the north and north-west of Catforth, appear on the map of Yates and Billinge (1786), though omitted on the earlier maps, probably because of inaccurate surveys; neither is marked on early nineteenth century maps. The small marsh at Thornton, also, was reclaimed by the beginning of the nineteenth century. Although earlier evidence of its existence is available, this marsh is first shown on the 1786 map as a small V-shaped area from the coast. In December, 1798, however, a private act for reclamation of this marsh was promoted and passed.<sup>5</sup> In the accompanying petition the marsh is said to have occupied 800 statute acres.

As regards the north of the Wyre, Dr. Pococke (1745) wrote,<sup>6</sup> 'From Pyling we passed near Preesall, and in about three miles came to Stalmine, having gone on two side of Pylin moss or bog' (i.e., the west side), and later at Garstang, 'we saw to the west the great moss or bog of Piling.' During this period the moss is shown as a single compact area under the collective name of Pilling Moss on the maps of Bowen (1767), Yates and Billinge (1786) and

<sup>1</sup> *Op. cit.*, p. 179.

<sup>2</sup> Duchy Pleas, Accounts and Inv., post, mort., passim.

<sup>3</sup> *History of Poulton-le-Fylde* (Chetham Society).

<sup>4</sup> Topographical account of Lancashire.

<sup>5</sup> *Commons Journals*, LIV., p. 83.

<sup>6</sup> Camden Society publs. of his journey.



Harrison (1789). In the map of Yates and Billinge, however, along the line of the stream from Nateby to Pilling, the main area of Pilling moss was separated from the section lying in Cockerham except at a point south of Bonehill. Moreover, in the south a road marked in dots across the moss from Rawcliffe to Stalmine, and the presence of Skitham and Heskham Houses on it, indicated the coming separation of the moss of Upper Rawcliffe. Finally, an enclosure of solid land appears to the south of the town of Pilling. On maps of Greenwood (1818) and Hennet (1828) the marsh of Cockerham is separated from the Pilling area along the line of the stream from Nateby to Pilling, while roads divide the Pilling moss west of the stream into two almost equal areas and a smaller patch called Out Rawcliffe moss. South of the road from Rawcliffe to Garstang there is the moss of Rawcliffe with Tarnicar. However, a petition for a private enclosure bill (February 16th, 1825) said that these mosses were still liable to flood and overflow,<sup>7</sup> and in 1833 a private bill legalised reclamation and enclosure, though in Pilling itself the work was done under the General Enclosure Act.

Little change had occurred by the time of the survey for the 1842-9 1 inch O.S. map. The eastern half of Pilling moss is divided into two halves, while Out Rawcliffe moss now occupied an extremely small area. Similar reductions had occurred in the size of the moss of Rawcliffe with Tarnicar, but Cockerham moss still remained largely unchanged. On the 6 inch map of 1891 reclamation is virtually complete in the area west of the stream from Nateby to Pilling, that is, in the moss of Pilling, Rawcliffe, Stalmine and Tarnicar, much less than five per cent. remaining as moss.

In Cockerham, though considerable progress was made in this period, a comparatively large area of moss about one mile long from north-east to south-west and half-a-mile from north-west to south-east still existed, but round it considerable progress had been made. Several isolated marsh fields within the circle of the road to the west through Moss House, Moss Edge and Moss Farm, and similar patches south of Winmarley indicated the former extent of the moss. In the 1911 survey all the isolated marshy fields had disappeared, and only the names on the map indicate their former existence, while the sole remaining moss of Cockerham had greatly shrunk, and Crowley's Dyke dividing it showed reclamation in progress.

Thus, in the later eighteenth century, the moss round Marton, and, in the second half of the last century, the mosses to the north of Wyre yielded to organised reclamation.

Marton Mere was formerly a very large expanse of water some six miles by one-and-a-half miles lying north of the moss already described, and as such it was marked on all the maps of this area until the late eighteenth century. During the mediaeval period it was important for both fishing and water supply; a thirteenth century grant from Theobald Walter le Botiller gave the abbots of Stanlawe the right to make a pool and use the water for their mill at Staining,<sup>8</sup> while the fishing rights were let out separately.<sup>9</sup> However, with the process of silting the mere became more and more like the surrounding

<sup>7</sup> Commons Journals, 16th February, 1825.

<sup>8</sup> Coucher Book of Walley Abbey, p. 424.

<sup>9</sup> Lancashire Survey. Chetham Society, LXXIV., p. 55.



moss in character, and it is difficult to consider the draining of the moss and mere separately.

Thus the 1731<sup>10</sup> proposal of drainage was concerned with a 'standing poole or water,' but in 1780 it was stated that 'such a fall is obtained that if the land-owners in Marton perform their part the moss will be effectively drained.'<sup>11</sup>

By the beginning of the nineteenth century, therefore, the maps indicate an area of water less than a mile square, and by the present time the site of the mere is marked by one of the few remaining areas of incompletely drained moss.

## VI.

# HISTORICAL GEOGRAPHY

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PHYSICAL conditions, and especially the mosses, suggest reasons for paucity of prehistoric finds. The Pennines and their slopes towards the Fylde have yielded small worked flints of types which were brought into Britain with or after the disappearance of the Pleistocene Ice, but lasted on in use in some cases until the historical Middle Ages, and they may accordingly be found along with objects from later periods. In the latter half of the third millennium B.C., there spread into Britain the arts of cultivation, stone-grinding, pottery-making, and so on, and at about the same time there developed coastwise maritime intercourse. Ground or polished stone implements have been found in a few places in the Fylde, two at Weeton, two near Blackpool, and one at Salwick, but these again need not antedate such changes as the introduction of metals; they also remained in use afterwards for a time. A flat bronze or copper axe with lateral expansion of the edge has been recorded near Pilling Hall. Weeton has yielded a bronze axe of the type with high flanges, but, as yet, no transverse stop-ridge, while from Marton there is one with a stop-ridge and a lateral loop for attachment; this latter had a handle a yard long when it was found. A hoard of eight socketed celts, some spear-heads and a dagger was found at Winmarleigh Moss, Over-Wyre, in the early nineteenth century, as also a spear-head in Stalmine Moss, Over-Wyre, and two socketed leaf-shaped spear-heads near Preston. At Copthorpe, near Garstang, about a mile from the Winmarleigh find, there was found a bronze sword of Peake's Type B, 27.5 inches long, with six medium rivet holes.<sup>1</sup> No pottery that might antedate the introduction of metal is known from the Fylde, but cinerary urns of the Bronze Age are known from Weeton, and, some distance inland from the Fylde, at the interesting monument at Bleasdale. Here a circle of oak posts surrounded by a timber-lined ditch had a fore-court between the above circle and an

<sup>10</sup> *History of Poulton-le-Fylde*. Chetham Society.

<sup>11</sup> *Ibid.*

<sup>1</sup> See *Antiq. Journal*, April, 1934, pp. 178-80, note by Dr. J. Wilfrid Jackson.

eccentric outer palisade. The monument is apparently to be dated fairly late in the Bronze Age, and is unique in view of the fact that the actual wooden posts and ditch-lining were found. They are preserved with the urns (which are of a type found in the Pennines) at Preston Museum, and the sockets of the posts have been appropriately marked by Mr. W. J. Varley. The monument appears to be related to the emergence of a trans-Pennine route on to the Lancashire lowlands.

Cairns of uncertain date occur near South Shore, at Blackpool, as well as near Hardhorn, Salwick and Weeton. Two ancient dug-out canoes have been found near Preston, as also a group of human skulls. Marton has yielded two skin-canoes, and Stalmine, Over-Wyre, a fibula and some other objects; these last finds may be of Roman, or perhaps pre-Roman date. Roman pavement occurs near Kirkham and near Fleetwood, and a few other items, including coins, have been found. There was a Roman Causeway from the neighbourhood of Ribchester, through Kirkham and on to Little Poulton, and, perhaps, Fleetwood. This was later known as Danes Pad, and consisted of a lower path three yards wide composed of shingle, and hard enough for horses, and a higher sandy one 10 yards wide for foot soldiers. A drainage trench separated the two, and it is likely that the lower one was a prehistoric trackway, especially as a number of the relevant finds made in the Fylde have come from near it. Kirkham was a pre-Roman site, apparently adopted by the Romans during a temporary military occupation.

Like the remainder of the north-west of England, north Lancashire, including the Fylde, was for a time in the possession of Celtic-speaking people. The river name, Wyre, and the village name, Treales, are Celtic, and there are others, with which another article is dealing.

Athelfrith of Northumbria (613) conquered Lancashire south of the Ribble, and a later king, Oswy, took Ribchester and north Lancashire. When Mercia became the leading power it took Lancashire south of the Ribble, and this distinction between the north and south of the county long maintained itself ecclesiastically, the north remaining in the diocese of York until 1541.

It is thought that the Danes attacked the Fylde between 869 and 894. The Danes were defeated in the Ribble valley about 911, and a hoard of silver coins at Overdale has been supposed to be the treasure of their army. In the Fylde the Danes settled either near the shore (Warbreck, Norbreck, Anchorsholme), or near the Roman Road which, as stated above, became known as Danes Pad. The Wyre entry was also fairly densely occupied, as place names show. Names ending in -ham and -ton, on the other hand, and some others, are thought to point to settlements of earlier date by people from Northumbria. The division into hundreds occurred in the late ninth century, when Danish invasions were very active, and the hundred-name, Amounderness (Agemunderness in 930) is Danish. Lancashire is not mentioned as such in Domesday, but Henry I. created the Honour of Lancaster in 1118, and this determined in a general way the outline and extent of the county.

At the time of the Domesday Survey a great deal of the Fylde was waste, but the most settled part seems to have been in the later parishes of Bispham-with-Norbreck, Carleton and Thornton, with eight, four and 10 ploughlands respectively on the alluvial soils of the peninsula; the first-named was in a



large measure under cultivation. Nucleated settlements seem to have arisen at Poulton, Kirkham, Little Marton, Layton, Bispham and Singleton, apparently names due to Northumbrian settlers, while it has been said that Danish settlements were inclined to straggle along a road. Elswick is an interesting type of village with three parallel roads, the middle one the chief, and cross connections; Newton has analogies with it. 'Double' villages occur in the Fylde named *great* and *little* respectively, e.g., at Marton and Bispham.

Mediaeval conditions in the Fylde went on into the seventeenth century, by which time, however, the name Fylde had come into use as a general designation, showing a popular consciousness extending beyond the manor, but the areas important at the time of Domesday remained important still.

The villages are mostly at or above the 25 feet contour, and the lower limit of cultivated land, of old days, might be about 20 feet, or the edge of the moss. Most land below 20 feet remained as waste or hawes with common rights of pasturage and of gathering rushes for thatching; much of this old waste land is now split up into smallish fields drained by dykes. The old cultivated fields were often called townfields, and were divided into strips for the families of the village as usual. More land might be added from the waste when necessary, and apparently monastic influence, exerted from Lytham, promoted this. Towards the eighteenth century enclosures took place, and pasturing and individual cultivation, followed by the spread of the practice of marking, came into general use, large landowners generally profiting at the expense of the small ones. There are no Acts of Parliament about enclosure of common fields in the Fylde, but several from 1761 to 1801 deal with enclosure from the waste, a process which, accompanied by drainage, had begun early in the century; and before the end of the eighteenth century nearly all common fields had been enclosed, and the Fylde had become the granary of Lancashire, a change accompanied by a notable development of windmills.

Not far from the Fylde is the ancient chapel of St. Patrick at Heysham, a reminder of the influence of the Celtic church. The hundred of Amounderness came to be attached ecclesiastically to York, but Lancashire between Ribble and M<sup>er</sup>sey belonged to the diocese of Lichfield from 923 onwards until 1541.

When archdeaconries were created, Amounderness was in the archdeaconry of Richmond, and Lancashire between Ribble and Mersey in that of Chester. A see of Chester was created in 1541, and Lancashire was divided into two archdeaconries belonging to it. Modern changes have brought Amounderness first under Manchester and then under Blackburn. Professor James Tait infers that churches existed at Kirkham, Poulton and St. Michaels-on-Wyre at the time of the Domesday Survey, and the two first are mentioned in a document of 1093. In a *Taxatio* of 1291 additional parishes of Lytham and Garstang are mentioned. By the end of the twelfth century a Benedictine priory had been founded as a dependency of Durham at Lytham with a dedication to St. Cuthbert inherited by the modern church.

Just beyond the Fylde to the north-east were the Praemonstratensian abbey, St. Mary of Cockersand and a house of Austin Canons at Cockerham. Ecclesiastical records indicate that the district suffered very severely from the



Black Death. By the seventeenth century, in addition to the old parish churches already mentioned, there were churches or chapels at Bispham, Singleton, Elswick, Lund, and a new church then built at Marton as, it was stated, the people of Layton, Rakes and Blackpoole hamlets had often been cut off from any church by water in winter. Lund is mentioned as an oratory as early as 1349, but it is supposed to have gone out of use between the Reformation and the Commonwealth. It contains a font modified from a Roman altar. The Fylde area seems to have been conservative at the time of the Reformation of the sixteenth century, and to have had some families which long subsequently remained Roman Catholic. Most of the Fylde churches have been rebuilt within the last two centuries.

## VII.

# THE CLIMATE OF THE FYLDE

BY

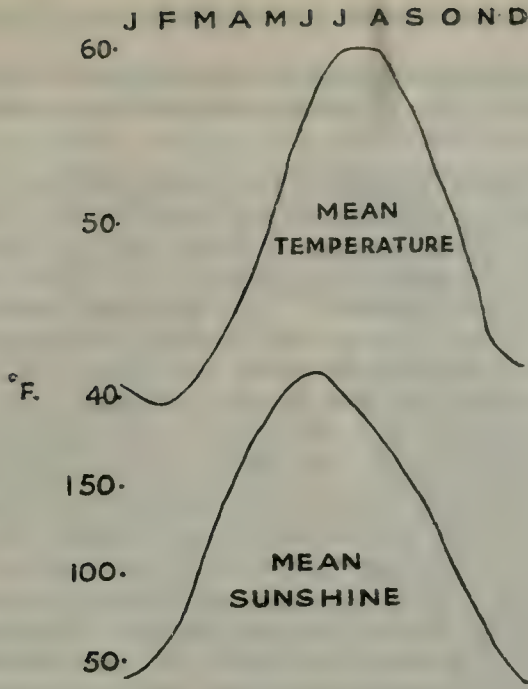
WILFRED SMITH.

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THE Fylde has the mild climate of the western seaboard of Britain. The mean temperature of Blackpool for February, the coolest month ( $39.9^{\circ}\text{F.}$ ),<sup>1</sup> is higher than that on the east coast, but below that in North Wales or the South-western Peninsula. From October to May, inclusive, frost is liable to occur but for each of these months there is at least one instance during the years 1900 to 1934 in which none has been recorded. Snow rarely lies on the ground for more than two or three days, and occasionally none falls throughout the winter. There is a marked contrast in this respect between the Fylde coast and the industrial area of Lancashire and the West Riding. The mean temperature of the warmest month (barely  $60^{\circ}\text{F.}$ ) is lower than that on the east and south coasts, but above that in Anglesey or the Isle of Man; the summers, though warm, are rarely hot. The range between night and day is slightly less than for inland stations in Lancashire with a similar mean temperature, partly owing in summer to the phenomenon of the land and sea breeze (v. i.).

The Fylde has a relatively low rainfall for the west coast. The lowest falls of the whole western seaboard occur in the Dee Estuary and the Wirral Peninsula, in the rain-shadow behind North Wales. Thence rainfall gradually increases northward along the Lancashire coast; it is 2 to 3 inches more at Liverpool than in the Dee Estuary, and 3 to 4 inches more at Blackpool than at Liverpool. But the mean rainfall at Blackpool for the 35 years 1900-1934

<sup>1</sup> The means for Blackpool, which are quoted to indicate the general climatic features of the Fylde, refer to the years 1900-34, a 35-year period.

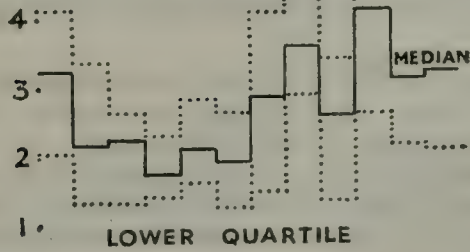


HOURS.



INCHES.

UPPER QUARTILE



INCHES.

MEAN PRESSURE



is only 35.67, compared with the postulated 40 inches as the average general rainfall of the British Isles. Eastwards this level is not reached until the land rises up the slopes of Bowland.

Rainfall is least from February to June, with a minimum in April ; it rises in July and in August reaches a level twice that of April ; it falls in September, but rises again in October as high or higher than in August ; it is less in November and in December and January, and is at a level intermediate between October and September. The transitions between the relatively dry season of February-June and the relatively wet season of July-January (with a break in September) are graded and without discontinuities, in the sense in which the term is used by Crowe and Matthews (see footnote). The range of variation or dispersion within each month is indicated by the quartiles given in the statistical tables.<sup>2</sup> It will be seen that the lower quartiles of July and September are as low as the lower quartiles of the months—February to June inclusive—of the relatively dry season, but that their upper quartiles are much higher than the upper quartiles of March-June. In other words, one quarter of the rainfalls of September are as low as one quarter of the rainfalls of April, but while there are very wet Septembers (e.g., September, 1935), the rainfall of April is never very high. July and September are clearly intermediate between the relatively dry and relatively wet seasons, sometimes belonging to the one and sometimes to the other. But the lower quartile of August is the highest of all and, ironically in this holiday month, the expectation of rain is the greatest.

The wide range between the sunshine maximum of June and minimum of December implies that the influence of solar control is accentuated by the contrast of anticyclonic weather and clear skies in the former, and of cyclonic weather and cloudy skies in the latter. On the Lancashire coast sunshine is at a much higher level than in the inland districts nearer to the foot of the Pennines, whether they be industrial or not. In the industrial districts domestic and factory smoke still further obscures the sky, so that sunshine is often only two-thirds of what it is on the coast. The discrepancy is greatest in December and January when the industrial towns receive on the average less than one hour's sunshine daily. In summer the extra sunshine of the coast is a contributory meteorological factor in the temporary seaward migration of population.

The land and sea breeze circulation considerably reduces summer heat along the Fylde coast. It is developed only during calm, anticyclonic weather. The sea breeze develops during the forenoon from the south-west, gradually freshens and veers through west to north-west in the afternoon. It dies down about sunset and a light land breeze from the east soon develops and blows until daybreak, after which it gradually veers through south-east and south to emerge again as a sea breeze in the forenoon. The effect of the sea breeze is usually pleasant, for the sunshine remains, though the air is cooler, but occasionally a distinctly unpleasant 'sea-fog,' half-saturated with vapour drawn up from the sea by the hot sun, spreads over the coast. This circulation

<sup>2</sup> For a discussion of the value of the median and quartiles in rainfall interpretation see papers by P. R. Crowe and H. A. Matthews in the *Scottish Geographical Magazine*, March, 1933, and March, 1936, respectively.



is purely a product of convectional causes and is confined to the summer half-year when the air over the land is warmer than over the sea. Dry summers with anticyclonic weather such as 1911 and 1921 are particularly favourable to its development. The daily anemometer charts for these two years at Blackpool show that it was most frequent in May, June, July and September and less frequent in August. During the six months April-September, inclusive, the sea breeze was developed on 21 per cent. of the possible occasions. These years were exceptional, but this circulation is an important element in the seaside climate.

In its more general features the climate of the Fylde is uniform, but there are some interesting differences both between the sands and the clays and between the several seaside resorts. The differences in *soil* temperature between the sands and clays are significant. The sand (at St. Annes) is as much as 2°F. colder in winter than the clay (at Blackpool), but warms up more quickly in the spring, and is up to 4°F. warmer in the summer. The differences are more pronounced at 4 feet than at 1 foot below the surface. They are of considerable agricultural importance and help to explain why there is market-gardening at Marton on the warmer sandy soils. The differences between the seaside resorts are easily perceived, but more difficult to understand. Blackpool is described as having a more bracing climate than St. Annes.<sup>3</sup> The mean temperature of St. Annes, however, is practically identical with that of Blackpool, except in winter, when it is slightly lower. The mean maximum monthly temperatures are a little lower at St. Annes, but the mean minimum are slightly higher, except in the mid-winter months. It is these somewhat higher minimum temperatures which explain the common impression that St. Annes is the warmer of the two. The only general inference that can be drawn from the humidity tables is that St. Annes has a somewhat lower humidity, except in spring, due no doubt to its porous, sandy soil and lower rainfall. The record at St. Annes is too short to allow of an accurate statement, but, on the evidence of the 11 years available, St. Annes rainfall is about 7 per cent. below that of Blackpool. St. Annes has thus a slightly drier and less humid climate, with rather higher minimum temperatures. Differences of elevation and exposure as well as of soil account for the contrast. St. Annes stands on a low-lying sand-dune coast. Blackpool is mainly built on low cliffs, which implies freer movement of air and is one of the causes of its more 'bracing' character. Blackpool and St. Annes have been selected as examples of the differences which obtain, as they have the longest series of records available.

<sup>3</sup> The data available for St. Annes covers only an 11-year period (1924-34), so that conclusions based on them can only be tentative. For a discussion of the difficulties involved in interpreting the differences between 'bracing' and 'relaxing' climates see papers by W. F. Tyler and E. Gold in *Quarterly Journal, Roy. Met. Soc.*, July, 1935.

## CLIMATIC STATISTICS FOR BLACKPOOL, 1900-1934.

|  | Jan.   | Feb.   | Mar.   | Apr.   | May    | June   | July   | Aug.   | Sept.  | Oct.   | Nov.   | Dec.   |
|--|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Mean Rainfall. Inches.<br>(Corrected to a 30-day month.) | 3.15   | 2.50   | 2.24   | 1.97   | 2.37   | 2.18   | 2.87   | 3.86   | 3.02   | 3.83   | 3.56   | 3.52   |
| Rainfall. Inches :—                                      |        |        |        |        |        |        |        |        |        |        |        |        |
| Median     ...     ...                                   | 3.27   | 2.18   | 2.28   | 1.72   | 2.13   | 1.98   | 2.91   | 3.66   | 2.59   | 4.11   | 3.11   | 3.22   |
| Upper Quartile     ...     ...                           | 4.10   | 3.39   | 2.67   | 2.30   | 2.86   | 2.44   | 4.09   | 4.45   | 3.42   | 4.95   | 4.59   | 5.06   |
| Lower Quartile     ...     ...                           | 2.04   | 1.34   | 1.31   | 1.42   | 1.65   | 1.29   | 1.56   | 2.97   | 1.38   | 2.69   | 2.21   | 2.13   |
| Mean Temperature. °F.     ...                            | 40.1   | 39.9   | 42.0   | 45.7   | 51.4   | 56.4   | 59.9   | 59.4   | 55.8   | 50.3   | 43.5   | 41.2   |
| Daily Mean Sunshine. Hours     ...                       | 1.46   | 2.43   | 3.90   | 5.58   | 6.38   | 7.05   | 6.26   | 5.53   | 4.71   | 3.17   | 1.92   | 1.15   |
| Mean Pressure. Millibars     ...                         | 1014.0 | 1013.7 | 1011.8 | 1012.6 | 1014.7 | 1015.5 | 1014.3 | 1013.1 | 1016.2 | 1013.1 | 1012.1 | 1010.7 |

## VIII.

## MAIN CENTRES OF POPULATION

BY

R. E. THOMPSON.

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At the opening of the nineteenth century a very even distribution of population reflected the agricultural character of the Fylde. Town life had developed in two centres only, namely at Kirkham and Poulton. As the oldest settlement in the district and suitably placed with reference to the principal agricultural areas, Kirkham naturally developed into the local market town. The occurrence of a small patch of sand and gravel here had encouraged settlement by the Northmen, for the site afforded spring water, which was a rarity in the district, covered as it was by boulder clay. One of its chief activities was the cattle fair, and, though the market is now obsolete, three cattle fairs are held each year. Before the Norman Conquest the parish of Kirkham embraced no less than 33,564 acres. In its parish registers of 1539 is the oldest entry in the whole of the Fylde. In 1829 came the introduction of industry based on the importation of flax and hemp from Belfast *via* Poulton. This gave rise to the manufacture of sail cloth and cordage, coarse and fine linen and some cotton under the instigation of the local gentry. While the production of 'waste' is still carried on, cotton weaving has become the dominant industry and is under the control of the Preston Chamber of Commerce. An interesting development has been the erection of a shed, the ground space of which is partitioned out and rented to individuals for weaving machinery as an encouragement to private enterprise. The township of Kirkham has grown up along the main Blackpool-Preston road, but industrial development has spread to the North along the road to and including Wesham, so that the towns are now co-terminous, the stream in the depression between them acting as the parish boundary. The increasing population of this zone was outstanding in the nineteenth century in contrast to the shrinkage of population in the surrounding agricultural districts.

It was inevitable that some maritime life should develop at the mouth of the Wyre. Here is a bottle-necked estuary, which was early recognised as a suitable harbour for shipping in the phrase, 'safe and easy as Wyre water.' It is possible that the Poulton area was originally settled by Saxons at the point where the Dane's Pad crosses the river Wyre. Domesday remarks that its parish possessed two carucates (266 acres) of agricultural land. The actual port was at Skippool, but because of danger of flooding, the customs and commercial centre was located at Poulton. In 1590 the vessel trade to Russia must have been equal to that of Liverpool. The trade consisted mainly of tallow, flax and hemp, but afterwards there sprang up an entrepot trade in cotton, corn, timber and flax from Belfast, which was shipped to many points



abroad. The trade in flax with Russia gave rise to a factory for sacking, sack cloth and sheeting, with flax dressing and twine spinning in 1816. After the middle of the nineteenth century, however, the port of Skippool could no longer compete with the facilities for ocean traffic now afforded by Fleetwood, so that Poulton's commerce declined, and thereby the town lost its significance.

The open aspect of the Fylde allows the westerlies to sweep unhindered inland, and imparts to the coast a freshness and clarity of atmosphere particularly associated with Blackpool. Here are other elements—firm sands, cliffs, accessibility to drinking water (tapped from the Bowland Hill drainage), and proximity to the industrial population of Lancashire—all essential factors of the success of a holiday resort. The undrained mosslands and bad roads prohibited development, however, until the nineteenth century. Speed's old map shows the site to be a large pool half-a-mile in width, situated half a mile from the coast. It was drained by a small stream from which "Black Pool Town" derived its name. A member of the Tyldesley family built a residence here at the beginning of the eighteenth century, and attention was first drawn to the spot by the arrangements he was making for hiding the Young Pretender. The name "Blackpool" first appeared on a map by Kitchener in 1750, while Bowen's map of 1771 shows a little towered house to the north of the Black Pool. The local gentry were the first to use the village as a resort after the racing at Langton Hall, and in 1783 a regular coach service from Manchester was established. Those who had successfully sought refuge here from the cholera scourge of 1831 testified to the healthiness of its site, suitability of accommodation and the attraction of its sea front. There were no less than 1831 visitors in 1837.

The success of Blackpool has encouraged other centres along the coast to attract holiday visitors, and a continuous line of habitations from Lytham to Fleetwood is no remote possibility. Lytham St. Annes is largely residential in character, though at one time a large pool existed to the east of Lytham, which was utilised as a dock by large ships prevented from reaching Preston owing to the state of the Ribble. The growth of the long sandy 'stanners' left by the tides affords a very gradually sloping beach, while the sandy sub-soil of the interior forms an excellent foundation for golf courses. The site of the town on sand is also said to assist rapid evaporation, which, preventing damp, makes it attractive to invalids. Its growth has been specially noticeable since the beginning of the present century. With less than 8,000 people in 1891 it has risen to over 25,000 in 1921.

Fleetwood may be cited as another example of 'mushroom' growth along this littoral. Although it attracts a fair share of the holiday traffic, its commercial undertakings have been more prominent. A hundred years ago the district was a virgin tract of sandy waste. The advantages of its site for a dock within the Wyre mouth, where a deep channel connects it with Morecambe Bay, were first recognised by Sir Peter Fleetwood, who, as Lord of the Manor, was responsible for the formation of the Preston and Wyre Railway, Harbour and Dock Company. A harbour was constructed and linked by rail to Preston, and by 1841 the town had assumed considerable proportions. Trade with Belfast in cattle was followed by connections with South Africa (guano), Russia (flax), the Baltic countries (timber), and the U.S.A. (cotton). The

tonnage dealt with at the harbour increased from 560 in 1850 to over 22,000 in 1875. The success of this venture led to the construction of a new dock in 1877, and Fleetwood became the base for a fishing fleet of considerable size. Vast quantities of hake, haddock, cod and flat fish are regularly landed at the port by steam trawlers and smacks frequenting the North Sea and West Irish coast. Another important industry is the culture of American oysters, which are imported and fattened up for the market. The discovery of a rock-salt bed at Preesall, two miles east of the port, was naturally of prime importance to the fishing trade. In addition, the brine is now conveyed by pipes to the town to serve the United Alkali Company's works set up in 1885 to produce ammonia soda. The works utilize 3,000 tons per week, while the main centres of the Company at Widnes, St. Helens and Glasgow have been supplied with rock salt from Preesall since 1894. Since the foundation of the port the population has increased rapidly. Attaining 15,000 at the beginning of this century, it exceeded 25,000 in 1921. In spite of these commercial aspects, Fleetwood has continued to attract an increasing number of holiday-makers, and this activity, more and more, is shaping the character of the Fylde seaboard.

## IX.

## THE PLACE NAMES OF THE FYLDE

BY

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IN the present brief survey *the Fylde* is taken in a slightly wider sense than usual, and to embrace the flat district west of the main road from Preston to Cockerh m, that is, the parishes of Kirkham (western part), Lytham, Bispham, Poulton-le-Fylde, St. Michael-on-Wyre, and parts of Preston, Lancaster and Garstang. The name *The Fylde* is from Old English *gefilde*, 'plain'; it also enters into the names Poulton-le-Fylde and Fieldplumpton (formerly *Fildeplumpton* and the like).

Place-names embody important historical material, and those of the Fylde bear remarkable witness to the varied racial history of the district, more varied than that of most parts of England, or even of Lancashire.

There is a remarkably strong sub-stratum of British names. Wyre, Cocker, Savick (Brook), perhaps Pilling are old British river-names. Wyre may be identical with Gaulish *Vigora*, while Cocker comes from an old adjective meaning 'winding.' British river-names are common all over England, but what is remarkable about the Fylde is that so many villages or hamlets have wholly or partly British names.



Tulketh, near Preston, is identical or cognate with *Toulhoet* in Brittany, *Tullcod*, near Llandaff, and means 'hole in a wood.' In Kirkham are Treales (formerly *Treueles*, identical with *Treflys* in Carnarvon, 'the court of the settlement' or 'village with a court'), Preese (from Welsh *prys*, *pres* 'brushwood'), Little Eccleston, which has as first element an early form of Welsh *eglwys* 'church.'

Not far from Preese, in a detached part of Lancaster, is Preesall, whose first element is Welsh *prys* or *pres*. In St. Michael-on-Wyre is Great Eccleston (near Little Eccleston), and Inskip possibly contains Welsh *ynys*, 'island.' There are few areas in England with a similar number of British names within a small circuit. There must have been a considerable survival of British communities in early Anglo-Saxon times, possibly due to the fact that parts of the Fylde must have been difficult of access owing to the marshy nature of the district.

The English settlements in the Fylde must be very old, and the first settlers were Northumbrians. Some place-names make the impression of being very ancient, as the names in *-ing* (Bryning, Staining); Whittingham just outside the Fylde may also be mentioned here. English names are in the majority among names of villages or townships. They are of the usual types. Names in *-hām* are Bispham, 'the bishop's manor'; Kirkham. Names in *-tūn* are common, as Clifton, 'tūn on a slope'; Hambleton, '*Hamela's tūn*'; Newton, Plumpton, 'plumtree tūn'; Thistleton, Warton (first element OE *weard* 'watch'), Weeton, 'willow tūn' in Kirkham par.; Layton (first element OE *lād*, 'water-course') in Bispham par.; Marton 'tūn on Marton Mere'; Newton, Poulton, 'tūn on a pool'; Thornton in Poulton par., Woodplumpton in St. Michael-on-Wyre. There are two names in *-wīc* (OE *wīc*, 'dwelling'), viz., Elswick, '*Ethelsige's wīc*,' and Salwick, '*wīc among salallows*.' Cottam is OE *cotum* dat. plur. of *cot*, 'hut.' Wesham, formerly *Westhusum*, is '(at) the western houses.' Lea is OE *lēah*, 'glade,' while Winmarleigh is '*Winmaer's lēah*.'

A fairly common element is OE *holh*, 'hollow,' as in Greenhalgh, Ingol, Stanah, Staynall. The English names are not evenly distributed. The south-western portion, Lytham par., has an English name itself, but there are few English place-names there. The same is true of the land north of the lower Wyre, where Ashton and Hambleton have English names, but most other places have Norse names. Both districts are low-lying and were apparently only to a small extent inhabitable or inhabited in early Anglian times.

The colonisation of these low-lying parts does not seem to have been carried out fully until the Norsemen came about 900, and the Norse element is particularly prominent in these parts. But Norse influence is strong in the whole of the Fylde. The hundred of which the Fylde forms a part is called Amounderness, *Agemundrenesse* in Domesday (1086), which is a Norse *Agmundar-nes*, '*Agmund's ness*.' This may be an old name of the Fylde, which forms a headland between the rivers Ribble and Cocker. If so, Agmundr will have been a Norse chieftain who held the district. He has been identified with the Agmund Hold who, according to the Anglo-Saxon Chronicle, was

† OE=Old English.



killed in 911. A *hold* was next in rank to an earl. But Amounderness may originally have referred to a special headland, e.g., Rossall Point.

Scandinavian influence shows itself not only in Scandinavian place-names, but also in modification (Scandinavianisation) of earlier English names. Both types of Scandinavian influence are noticeable in the Fylde. Rawcliffe is a Scandinavianised form of OE *Rēade clif*, 'red cliff, Redcliff.' Carleton is probably a Scandinavianised form of OE *Ceorla-tūn*, 'tūn of the churls.' Bradkirk, 'plank church,' is a modification of OE *Bred-cirice*, Kirkham one of OE *Ciric-hām*.

Scandinavian or Scandinavianised names are numerous north of the lower Wyre. Stalmin contains ON<sup>2</sup> *mynni*, 'mouth of a river.' Staynall is a Scandinavianised form of OE *Stān-holh*, 'stony hollow.' Rawcliffe is also Scandinavianised. Preesall is a hybrid containing a British name and an ON word for 'headland'; while Hackinsall is Norse *Hakuns haugr*, 'Hakun's mound.' Nateby is obviously Scandinavian, and Tarnacre contains ON *trani*, 'crane' or a personal name derived from it. Of minor names may be mentioned Eagland (ON *Eiki-lundr*, 'oak grove') and Skitham (formerly *Scytholm*).

In other districts we notice the curious circumstance that townships often have composite names consisting of one English and one Norse name, e.g., Bispham with Norbreck, Bryning with Kellamergh, Little Eccleston with Larbrick, Layton with Warbreck, Westby with Plumpton. Sometimes both are Norse, as Ribby with Wrea (Ribby from ON *Hryggbjǫr*, 'village on a ridge,' Wrea from ON (*v*)*rá*, 'corner, remote place'). Treales, Roseacre and Wharles contains one British name (cf. *supra*), Norse Roseacre (formerly *Raysacre*, 'field with a cairn,' ON *hreysi*) and English Wharles, from OE *hwerfel*, 'circle' and *hlāw*, 'mound,' the name very likely referring to the same ancient monument as Roseacre.

The Norse names include names of the usual types, as names in *-by* (Ribby, Westby, Sowerby, the last being ON *Saurbjǫr*, 'village by a marsh'). But some names belong to characteristic types and give important special information.

Place-names show that the Scandinavians in the Fylde were chiefly Norwegians, Norsemen, not Danes, as in the east of England. Danish and Norse place-names have certain distinctive features of their own. A Danish test-word is *thorpe*; there are no Thorpes in the Fylde. Norse test-words are *breck*, 'slope, hill' (from ON *brekka*), *scale*, 'hut' (from ON *skáli*). Names in *-breck* are common in the Fylde, as Larbrick (first element ON *leir*, 'clay'), Mowbrick (first element ON *Múli*), Norbreck, 'northern hill'; Swarbrick, (first element ON *Svarti*), Warbreck, 'beacon hill,' Esprick (ON *Eski-brekka*, 'ashtree slope'). *Scale* is found in Scales.

It is generally held that the Norse in Lancashire came over from Celtic lands in the west, Ireland, the Isle of Man, etc. Norse place-names here show unmistakable Celtic features. A common place-name element in the north-west is *erg*, 'shieling,' from OIR *airge*. It is found in some place-names in the Fylde, but it is not so common as in the hilly eastern parts of Amounderness. Kellamergh, which contains an Old Norse personal name, and Medlar, 'the middle *erg*,' are cases in point.

<sup>1</sup> OE=Old English. <sup>2</sup> ON=Old Norse.

Besides the early names mentioned in this article there are in the Fylde some names of later date, some designating places now important, towns or holiday resorts. The old capital of the Fylde was Poulton-le-Fylde, but its place has now been taken by Blackpool, which was formerly Layton with Warbreck. Blackpool was the name of a peaty-coloured pool in the township, which gave its name to a farm, called *Pull* in the thirteenth century. The name Blackpool is recorded from 1661.

Fleetwood, a town on the Rossall peninsula, grew up in the earlier half of the nineteenth century. It was named from Sir Peter Hesketh Fleetwood, the founder of the town.

St. Annes-on-the-Sea is now a seaside resort. The place took its name from a church built in 1873 and dedicated to St. Anne.

For a full treatment of the place-names of the Fylde I refer to my book, *The Place-names of Lancashire*, published in 1922 by the Manchester University Press.

## X.

# AGRARIAN EVOLUTION SINCE THE EIGHTEENTH CENTURY

BY

WILFRED SMITH.

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By the end of the eighteenth century the townfields of the Fylde had wholly passed under enclosure, although much marsh and moss remained as common waste and common turbary. The urge to enclosure was provided by the rapid growth of the industrial population of South Lancashire and in the eighteenth century the Fylde had become the granary of the county. It was asserted at the end of the century that Lancashire grew corn sufficient to satisfy her requirements for only three months in the year, and the significance of the Fylde as a granary is indicated by the abundance of windmills, eight of which still exist to-day. Enclosure, however, had here preceded the New Husbandry. The improved crop rotations worked out in Norfolk, and the improved stock bred by Bakewell, were only beginning to be introduced. The natural fertility of the clayey loams of the Fylde was abused by constant cropping for corn. 'Certain fields have been kept under cultivation, it is asserted, for more than a century without intermission,' wrote J. Holt, the Surveyor for the Board of Agriculture, in 1795. Oats were commonly sown for years together, varied occasionally by a summer fallow followed by wheat, or by beans and barley in alternate years, or by self-sown grass and weed seeds, which provided indifferent pasture prior to marling and renewed corn cultivation. Marling was the standard manurial treatment and marl pits, now filled with water, are still to be found in almost every field.



Oats was the most important cereal and oatmeal was still the labourer's staple food. Wheat was of relatively recent introduction—Leland early in the sixteenth century had remarked that 'Whete is not veri communely sowid in thes partes'—but at the end of the eighteenth century its use was increasing with the rising standard of living. The strong loams of the Fylde are good wheat soils as well as good oats soils, though the climate is rather too wet and not sufficiently sunny for the highest yields of grain. The continuous cultivation of corn left no room for turnips and although clover was more generally sown, the tenant was generally under a covenant not to sow clover as a preparation for wheat—in flat contradiction to the principles of the New Husbandry. Potatoes were, however, very intensively cultivated and more successfully, so it was claimed, than in any other part of Britain. They formed with oatmeal the standard diet of the labourer and the chats were fed to fattening cattle.

The Fylde at the end of the eighteenth century, though primarily a corn district, was not wholly so. Leland had noticed long before that of the enclosures more were for grass than for corn, but he was writing of the country east of the Fylde proper. In the eighteenth century the Fylde had been famed for its Longhorn cattle, and good stock implied good grass. At the end of the century more and more land was being laid down to grass partly because, so the Board's Surveyor reports, of the exhaustion of the land by the constant cropping for corn and partly because of the drainage of labour and capital away from farming to manufacture. Some of the new grass was self-seeded and of poor quality, but there was much good grass that carried a cow in milk to every one-and-a-quarter acres, according to Arthur Young, who travelled from Lancaster to Preston in 1771. The Longhorn, 'the prime stock of which is bred in the Filde,' was a general purpose animal. There had been big demands on the best stock in the course of the eighteenth century by breeders in Leicestershire and Warwickshire, and the Lancashire Longhorn formed the basis of Bakewell's improved herd. The Midland graziers transformed the Longhorn into a beef breed, but in Lancashire it was valued more for its milk. Its milk yield was, however, less than that of the improved Shorthorn and, although there were no Shorthorns in the Fylde at the end of the eighteenth century, they came to prevail there during the course of the nineteenth and the Longhorn has now entirely disappeared from the district. Dairying was mainly for cheese and the districts east of the Fylde proper still make the white Lancashire cheese. There were not many sheep kept at this time in the Fylde and they were mainly four-year-old Scotch Blackfaces fattening for the butcher. There were not many pigs either, which was a matter for surprise in view of the potato crop and of the cheese-making. On the other hand, there was an abundance of poultry: 'the Filde,' wrote Holt, 'is the principal district in this county which keeps a surplus stock of poultry.' Cattle and poultry as the major items, sheep and pigs as the minor, were the features of the stock economy of the Fylde at the end of the eighteenth century, as they are to-day. It is possible, however, that this stock-keeping was relatively more important east of the Fylde than in the Fylde itself. Of the six farms near Garstang and Cockerham, of which Arthur Young gives particulars, all had more land in grass than in arable.



By the middle of the nineteenth century the principles of the New Husbandry had become established in the district. The unending succession of corn crops had been replaced by a five or a six-course rotation which adapted the Norfolk four-course to the local economic and climatic conditions—oats, turnips or potatoes, wheat or barley, clover and rye-grass left down for two or three years. It had by this time become unusual to take two corn crops in succession, but where the practice survived the land was dunged heavily. The increasing head of stock kept increased the quantity of farmyard manure and leases often required its application to the arable every third year. Marling was ceasing to be general, the use of bone manure was becoming more common, and sulphate of ammonia from town gas works was just beginning to be used.

The relative proportions of arable and grass had already begun to change. Every farm by the middle of the nineteenth century had a considerable acreage in grass mainly on the strong land. Dairying, previously an important subsidiary objective, was becoming the rival of corn, and the Shorthorn was replacing the Longhorn because of its better milking qualities. The increasing head of stock which needed tying-up room in winter demanded the remodelling of farm buildings. House and barn formerly combined under one roof were now separate, and shippens were constructed round the yard. Many of the new courtyard farms came into being just after 1850. While the strong land was being increasingly laid down to grass, the reclaimed moss went into arable as soon as it came into cultivation, and helped to maintain the acreage under the plough. The mosses within the Fylde proper had wholly passed under cultivation by this time and those of the Over-Wyre district were in active reclamation, though their improvement was not completed until quite recently. By 1850 the present day economy was fast developing.

The accompanying table, which refers to the 25 civil parishes of the Fylde proper, enables us to gauge the rate of change statistically for the later part of the century. By 1870 (the first statistical returns were made in 1867) half of the cultivated land, excluding rough grazings, was under grass. This was a greater proportion of grass than in England and Wales as a whole but, relative to the rest of Lancashire, the Fylde was still an important arable district. Of the land under the plough, about half was in corn, a quarter in rotation grass, and another quarter in roots and bare fallow. These proportions indicate a four-course rather than a five or a six-course system. The two or three years' grass ley, though practised on some farms, was not universal. Of the corn crops, wheat had a slightly larger acreage than oats. Even in this district, with an average rainfall of considerably over 30 inches per year, wheat was still profitable to grow, for wheat prices did not begin to fall catastrophically until the next decade. The land was too heavy for barley, but there was a considerable acreage under beans. On the strong land there was a good deal of bare fallow, which was not necessarily bad husbandry on these wheat and bean soils. Of the roots, potatoes occupied a much greater acreage than turnips, swedes and mangolds. The turnip crop has never been very important in the district. The strong loams are wheat and bean land rather than turnip and barley land, and the moss soils yield such huge crops of potatoes that potatoes form their most obvious root break. Moreover, turnips were not required by the stock economy as much as in eastern England with its sheep folded on roots and bullocks fattening in the yard.

The Fylde was in 1870 an important stock district. Half the land was in grass and much of the arable produced fodder crops. There were more head of cattle than of sheep, and if the sheep be reduced to cow-equivalents the relatively smaller part of sheep in Fylde stock economy is clearly demonstrated. Of the cattle, rather more than half were cows and heifers in milk and in calf (the dairy herd), over one-third cattle under two years old, and only one-tenth cattle over two years old other than the dairy herd (mainly fattening stock). Compared with the country as a whole, the young stock were in about normal proportions, but the dairy herd was relatively more and the fattening cattle relatively less important. Clearly the Fylde was then, as now, a dairying and not a feeding district. The density of cattle per 100 acres of permanent grass was higher than for the country as a whole. The implication is that the grass was of relatively good quality, for the use of artificial feeding stuffs in summer cannot have begun on any extensive scale at this date.

From 1870 onwards change has been continuous. The acreage under the plough has steadily declined save for an increase during the later years of the Great War to the level of what it had been during the 1880-90 decade. It is now little more than one-fifth of the total cultivated land. The decline has been most pronounced on the strong loams, the corn-growing land of the eighteenth century and earlier, and least on the sands and reclaimed moss. By far the greater part of the arable in the Fylde is now on moss and sandy soils, and the strong land is predominantly in grass. The transference of arable from heavy to relatively light soils, newly brought into cultivation, amounted to a complete reversal of agricultural distributions and is a local example of a change common to the whole country. Within the reduced arable acreage there have also been changes in rotation. The proportion under corn has declined and under rotation grass has increased, save for the temporary reversal of the trend during the Great War. The proportion under grass reached its maximum immediately after the very low corn prices during the 'nineties,' when the long ley became particularly common. The acreage under wheat has declined continuously save for a temporary recovery during the Great War and the contemporary recovery due to the Wheat Act. In the Eastern Counties the recovery in the wheat acreage had begun in 1932, but in the Fylde it was delayed until 1933. In general the decline in wheat has been balanced by an increase in the proportion under oats, which is now the only corn grown on many farms. The grain most natural to the district has re-asserted its predominance. Barley and beans have practically ceased to be grown, and the practice of an occasional bare fallow has been discontinued. The disappearance of beans and bare fallow testifies to the withdrawal of the arable from the strong lands. The proportion under roots has increased, but particularly that under potatoes, for which there is a strong demand in industrial Lancashire. The steady increase in 'other crops' is to a large extent accounted for by market-gardening on the Marton Moss, near Blackpool, and in recent years by land under glasshouse cultivation both on Marton Moss and on the main Blackpool-Preston and Blackpool-Garstang roads.

There have been changes in stock of a somewhat parallel order. The size of the dairy herd has continuously grown, and there are to-day over twice as many cows and heifers in milk and in calf as in 1870. The dairy cow, with its requirements of grass and hay, now dominates the agricultural economy of the



Fylde. Dairying is for the liquid milk market and very little cheese-making now remains in the Fylde proper. Many farms, particularly those of small and medium size, have now no arable land at all, and few have more than one-third of their acreage under the plough. Where arable remains, the chief objective of cultivation is the provision of stock food, potatoes and wheat being usually the only crops sold off the farm. The number of young cattle grew side by side with the growth of the dairy herd until the end of the nineteenth century, but since that time they have steadily declined both relatively and actually. They are now too few to replenish cows drafted out of the dairy herd and many dairy farmers now buy in their stock newly-calved or about to calve from outside the district—from Ireland, from the Pennine dales, from the margins of the Lake District, or from South-West Scotland. On many farms the cattle are all cows or heifers in milk or in calf, with the addition of a bull. Milk is exported to the seaside towns or to industrial Lancashire and Liverpool. The Fylde helps to feed South Lancashire as it did in the eighteenth century, but the export is now of milk and eggs rather than of corn. The number of cattle being fed for the butcher has varied, but shows no pronounced trend. They are usually kept by a few specialist graziers or butchers, and many of them are imported Irish stores bought in at the beginning of the grazing season and mostly finished by its close.

The number of sheep has fluctuated widely. They have increased in recent years owing to relatively favourable prices for mutton and lamb. There has been a progressive change in the proportion of lambs and of adult sheep. In 1870 there were more adult sheep than lambs, but to-day the keeping of sheep in the Fylde is almost confined to the fattening of lambs for the seaside market, ewes being brought in from the hill districts of Northern England in the early autumn and sold fat with their lambs early in the following summer. The pastures are then left free for the dairy herd. The number of pigs has increased steadily throughout the period and is now over five times as great as in 1870. The increase has been general, but most pronounced in the neighbourhood of urban areas, where quantities of food refuse are available. Production is mainly for the pork market. The number of fowls kept has also greatly increased. Even in the eighteenth century the Fylde was an important poultry district. The most rapid increase was after the Great War, when specialist poultry farms with wired runs developed near the main roads. The general farmer has also increased his poultry business, and his fowls are now usually kept in flock houses in the middle of the pastures, instead of, as formerly, around the barn door.

These changes in farming practice have had their influence on the quantity of rural population. The position is complicated in some parishes by the growth of the seaside towns and by the development of residential settlement along the main roads, but in those not so affected the course of change is clear. Population increased from 1801 to 1821, but subsequently declined. By 1861 it had fallen to the level of 1801 and continued to fall until 1891, when it was about 90 per cent. of what it had been at the beginning of the century. Thereafter it has remained steady. In the moss parishes north of the Wyre the population continued to grow with reclamation and did not begin to decline until nearly the end of the century. The increase in the early years of the



nineteenth century was common to all rural districts in England, but the decline began earlier in the Fylde than in the country in general, owing to the more rapid laying down of land to grass. Rural population continued to decline in the Fylde with the progressive fall in the acreage under the plough but, despite the continued decline of the arable, the rural exodus ceased after 1891, owing to the greater number of head of stock carried per acre and the additional labour which they have required.

AGRICULTURAL STATISTICS OF THE FYLDE.

|  | 1870  | 1880  | 1890  | 1901  | 1910  | 1920  | 1930  | 1934  |
|--|-------|-------|-------|-------|-------|-------|-------|-------|
| Acreage under Crops and Grass ....                     | 45723 | 46873 | 48277 | 46125 | 47249 | 46190 | 41829 | 40539 |
| Percentage of Crops and Grass in Arable .....          | 45.9  | 35.9  | 32.4  | 28.7  | 24.9  | 34.0  | 24.2  | 21.1  |
| Percentage of Crops and Grass in Permanent Grass ..... | 54.1  | 64.1  | 67.6  | 71.3  | 75.1  | 66.0  | 75.8  | 78.9  |
| Percentage of Arable in Corn .....                     | 51.4  | 51.2  | 45.5  | 39.3  | 41.5  | 43.6  | 37.8  | 39.6  |
| Do. in Rotation Grass .....                            | 24.8  | 24.0  | 30.6  | 35.0  | 30.5  | 28.9  | 33.7  | 29.4  |
| Do. in Roots .....                                     | 15.1  | 18.6  | 17.4  | 19.5  | 19.8  | 20.6  | 20.5  | 22.8  |
| Do. in Bare Fallow .....                               | 7.9   | 3.5   | 2.4   | 1.2   | 1.5   | 1.7   | 1.3   | 0.3   |
| Do. in Other Crops .....                               | 0.8   | 2.7   | 4.1   | 5.0   | 6.7   | 5.2   | 6.7   | 7.9   |
| Percentage of Arable in Wheat .....                    | 21.6  | 14.2  | 13.3  | 8.8   | 7.2   | 10.0  | 3.8   | 11.5  |
| Do. in Barley .....                                    | 2.9   | 7.8   | 3.3   | 3.5   | 2.1   | 1.6   | 0.5   | 0.3   |
| Do. in Oats .....                                      | 20.2  | 22.6  | 25.2  | 25.9  | 31.5  | 31.8  | 33.4  | 27.7  |
| Do. in Beans .....                                     | 6.7   | 6.6   | 3.7   | 1.1   | 0.7   | 0.2   | 0.1   | 0.1   |
| Do. in Potatoes .....                                  | 9.6   | 13.1  | 12.2  | 15.0  | 12.6  | 13.2  | 13.8  | 16.5  |
| Do. in Turnips, Swedes and Mangolds .....              | 5.5   | 5.5   | 5.2   | 4.5   | 7.2   | 7.4   | 6.7   | 6.3   |
| Total Cattle .....                                     | 12555 | 15689 | 18582 | 20045 | 20974 | 20631 | 19676 | 22091 |
| Cows and Heifers in Milk and in Calf .....             | 6714  | 7619  | 8997  | 10579 | 12369 | 12890 | 13668 | 15366 |
| Other Cattle Under Two Years .....                     | 4601  | 5692  | 7289  | 7284  | 6887  | 5441  | 4408  | 4726  |
| Other Cattle Over Two Years .....                      | 1240  | 2378  | 2296  | 2182  | 1718  | 2300  | 1600  | 1999  |
| No. of Cattle per 100 acres of Permanent Grass .....   | 50.8  | 52.2  | 56.3  | 60.9  | 59.1  | 67.6  | 62.0  | 69.1  |
| Total Sheep .....                                      | 10003 | 15814 | 17562 | 14396 | 13065 | 6405  | 16692 | 19886 |
| Total Pigs .....                                       | 2500  | 2551  | 5186  | 5893  | 8193  | 8285  | 9328  | 14191 |

## XI.

## AGRICULTURE OF THE FYLDE

BY

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THE popular conception of Lancashire is of a blackened countryside, a region of smoking chimney stacks and sulphurous slag heaps, where the farmer must wring his livelihood out of 'the begrimed pastures that scarcely separate the towns.' This conception is true, however, only of a small proportion of Lancashire, and although the industrial activities of the county as a whole tend to overshadow its agricultural interests, Lancashire is one of the foremost agricultural counties.

Compared with other English counties, Lancashire ranks eighth in respect of the area under crops and grass, and tenth in respect of the area under arable cultivation. Potatoes, of which there were 37,180 acres in 1934, is the most important arable crop; only two counties have a larger area under this crop. The chief cereal crops are oats (52,346 acres) and wheat (30,145 acres); practically no barley is grown. In respect of live stock, Lancashire occupies an even more important position. In 1934, there were over 137,000 cows in the county, a larger number than any other county except Yorkshire.

Although over large areas of the county practically no sheep are kept, sheep-farming is important in the hilly districts of East and North Lancashire and in the Fylde, so that the sheep population is fairly heavy, being over 386,000, the county occupying ninth place amongst English counties in this respect. The pig population of over 115,000 is the seventh largest in the country, and represents an increase of nearly 40 per cent. in the number of pigs kept compared with 1930.

Even a summary of the agricultural statistics of the county would be incomplete without reference to the magnitude of the poultry-keeping industry. The agricultural returns show that in June, 1934, there were over seven-and-a-half million fowls kept on holdings of over one acre. If to this is added the estimated number kept on smaller areas, the total poultry population of Lancashire must be over 10,000,000. This is more than one-eighth of the total fowl population of England and Wales.

Arable farming is mainly concentrated on the plain which lies along the sea board between the estuaries of the Ribble and the Mersey; Ormskirk, where the National Institute of Botany has established a potato testing station, may be regarded as the centre of this area.

Between the western arable plain and the Yorkshire border is the great industrial area. The important manufacturing towns of Burnley, Blackburn

and Accrington, and of Bolton, Bury and Rochdale lie respectively on the northern and southern slopes of the Rossendale Fells, and these larger towns are linked up by an almost continuous chain of smaller industrial towns and villages. The soil in this area is poor, and the cultivated land is practically all under grass. The type of farming is determined by the proximity of the large industrial population. The farms are small and almost invariably devoted to milk production.

Although Lancashire farmers have had a very difficult time during the past few years, it may be said that on the whole they have been less affected by the recent depression than those in other parts of the country. Signs of the general neglect of the arts of good husbandry, so apparent in many parts of England, are not obvious in this county; there are few derelict farms, and on the whole the standard of cultivation has been well maintained. Farms have been good to let, and changes in tenancy have not been exceptionally numerous. There has been no reduction in the number of stock kept, or any general movement to reduce costs at the expense of production. On the contrary, so far as available capital would allow, the tendency has been to meet by more intensive production the situation created by falling prices.

### THE FYLDE.

The plain which in the south-west provides scope for intensive arable farming is continued north of the Ribble estuary as far as Morecambe Bay but the character of the soil changes, and a different type of farming is followed. This area, bounded on the east by the Preston-Lancaster line, and on the west by the Irish Sea, with the towns of Blackpool and Fleetwood on its coast line, is known as the Fylde, and it is proposed to deal in greater detail with the agricultural features of this region.

The climate is mild and open, with an evenly distributed rainfall. At the County Council Farm, Hutton, where the climatic conditions approximate to those obtaining in the Fylde, the average rainfall for the past 10 years has been 37.6 inches. Crops very rarely suffer from drought.

The soil, derived mainly from boulder clay overlying Keuper sandstones and marls, is generally a deep, fertile clay loam, but there are considerable areas of sandy loam, of peaty soil known locally as "moss" land, and a belt of light, sandy soil round the coast. On the sandy loam and moss soils, arable and market garden crops are grown, but on the deep loam covering most of the Fylde mixed farming is the rule, with 60-80 per cent. of the land under grass. Both the soil and climate are favourable to the development of good grassland.

Lancashire is chiefly a county of small farms worked mainly by the farmer's own family. In the Fylde, however, the farms generally are larger than in other parts of the county. There are a few farms of 250 to 500 acres, but the typical Fylde farm is between 50 and 100 acres. Rents are comparatively high. On the larger farms they usually range between 40s. and 50s. per acre, and on the smaller farms up to 60s. per acre. The minimum rate of wages for adult stockmen is 40s. per week of 60 hours, but most farmers pay rather more than this.



## DAIRYING.

Primarily the Fylde is a dairying district, and most of the farms carry a relatively heavy stock of milch cows. There are several herds of Friesians, but the usual breed is the non-pedigree dairy shorthorn or dairy shorthorn x Ayrshire. This latter is a very popular type, and is known as 'the cock-horned cow.' There are several well-known herds of pedigree shorthorn and Friesian cattle in the district.

Many farmers rear their heifer calves, but milk selling is the primary object, and reliance is placed chiefly on outside sources for herd replacements. Large numbers of cows come down from south-west Scotland, Cumberland, Westmorland and from the Yorkshire dales, whilst probably over 30 per cent. of the total number of cows kept are of Irish origin. Weekly cow sales are held at a number of country markets, but the main centre is Preston, where every Friday about 500 (including 150-200 Irish) cows in milk change hands. On alternate Mondays 300-400 in-calf cows are also sold in Preston market.

The operation of the Milk Marketing Board, by encouraging the sale of liquid milk, has increased the demand for cows and reduced the proportion of milk available for rearing, but some of the Fylde farmers, anticipating a scarcity of dairy heifers in the near future, are now paying more attention to the rearing of young stock.

Although most of the milk is sold in the liquid form, a considerable proportion is made into cheese, and, to a less extent, butter. The Fylde may be regarded as the home of Lancashire cheese, and the old stone cheese presses which must have been in general use 100 years ago may still be seen (though not in use) on many of the Fylde farms. Up to the advent of the Milk Marketing Board the cheese was made on the farms. Unfortunately the operations of the Board, in the first instance at any rate, had the effect of discouraging farm cheese-making, as farmers could dispose of their milk in the liquid form at a better price than they could obtain by converting it into cheese, as well as being relieved of the somewhat arduous labour of cheese-making.

As, except for the seasonal demand of Blackpool and other coast resorts, this milk could not be utilised for liquid consumption, a number of cheese factories were established in the area. As a result, the industry which has been built up by the Fylde farm cheese-maker has largely passed into the hands of manufacturers and factors, and this has accelerated the movement already in progress of putting cheese on to the market in a more or less immature condition. It is becoming increasingly difficult to obtain the more mature cheese which was available 20 years ago. The best Lancashire cheese is a whole-milk cheese with a clean acid flavour, and with a characteristic texture, which is due to the cheese being made of curd of different ages and at a lower temperature than is used in the manufacture of, say, Cheshire or Cheddar cheese. The Milk Marketing Board have now taken steps to secure that the home cheese-maker is not penalised compared with those who send their milk to the factories, and there has been some revival of home cheese-making during the past year.

Arrangements have recently been made for the grading of Lancashire cheese, and its sale under the National Mark. It is estimated that farmhouse and

factory cheese-makers who are participating in the scheme convert during the winter months about 20,000 gallons and during the summer months about 30,000 gallons of milk daily into Lancashire cheese.

### PIGS AND BACON.

With the large quantities of whey available as a by-product of cheese-making, pig-keeping is an important branch of farming in the Fylde. The Large White is the popular breed, and many excellent herds of pigs are found in the district. Owing to their high rate of breeding it is possible to rapidly adjust the numbers of pigs kept in accordance with economic conditions, and as the Pigs Marketing Scheme has brought a measure of stability to an industry which had been subject to severe cyclical fluctuations in prices, there has been some increase in the numbers of pigs kept in the Fylde. A number of farmers have erected new pig-houses of the Scandinavian type, and closer attention is being paid to efficiency in management and feeding, as it is recognised that the margin of profit provided under the scheme is so small that only under a highly efficient system of management will pig-keeping be found reasonably remunerative.

There is no large curing factory in the area, but there are a large number of comparatively small curers who cater for the demand for lean pork and fat bacon which is met with in Lancashire. For this purpose a pig of 10 to 12 score carcase weight is required, from which before curing a length of lean is cut out for sale as fresh pork, the thick back fat being cured for bacon. Although the larger proportion of pigs are probably sold under contract through the Pigs Marketing Board at seven to eight-and-a-half scores, a considerable number are still fed to the heavier weight to meet the special requirements of the Lancashire curer.

### SHEEP AND HORSES.

Sheep do not play an important part in Fylde farming, but small flocks are kept on many of the farms. Ewes are purchased from Scotland or from the hill districts further north and sold fat after one or two crops of lambs. The ewes are mainly Mashams—the progeny of the Wensleydale ram and the Swaledale ewe—or white-faced half-breds, the cross between the Border Leicester and Cheviot. These ewes are usually crossed with a Suffolk tup with the object of catering for the early fat lamb market. The Suffolk Masham cross is very popular with the butcher. Lambing is common in February, and the lambs are sold at carcase weights of 30 to 40 lbs. There is no root-feeding of sheep, but many farmers buy half-bred lambs at the autumn sheep sales in the north for feeding on seeds or aftergrass.

Beef-production in the main is confined to the feeding of cows no longer required in the milking herd, but some farmers make a practice of fattening a few cattle—mainly Irish stores—which are sold generally at about 8 cwt. live weight. The beef subsidy has helped to check the tendency to change over from beef to milk, and thus has indirectly helped the dairy farmer.

Mechanisation on the land is not highly developed. Small farms and small fields do not provide suitable conditions for the application of power to farming, and cultivations are carried out mainly by horse labour. A few



Clydesdales may be seen, but the Shire holds pride of place. There are some well-known studs of Shire horses in this district, and many farmers run one or more brood mares, and sell the offspring off for heavy town work at five and six years old.

### POULTRY-KEEPING.

Reference has already been made to the great importance of poultry-keeping in Lancashire, and the Fylde area may well be regarded as the most important centre of this industry. On the general farm, poultry-keeping is no longer regarded as a side-line providing pin-money for the farmer's wife, but as occupying an important place in the economy of the farm, and there are few farms in the Fylde where poultry do not make a substantial contribution to the farmer's income. There are also a large number of holdings devoted entirely to poultry-keeping. On the general farm, poultry flocks range from 500 to 1,000 birds, and there are many specialised poultry farms with a stock of from 2,000 to 5,000 birds. The main object of the poultry keeper is egg-production, and only as a by-product the breeding and feeding of table birds.

Up to recent years the usual practice has been for the egg-producer to raise his own stock for replacements, but latterly there has been a tendency towards specialisation, the stock being obtained from sources which specialise in the production and distribution of eggs for incubation, day-old chicks or young pullet stock. The popular breeds are White Wyandottes, White Leghorns and Rhode Island Reds, and these breeds comprise 90 per cent. of the poultry stock.

Birds are usually housed in a type of house known as the "Lancashire Cabin," a type which is now becoming generally used in other parts of the country. The standard size is 24 feet by 12 feet, capable of holding 100 adult laying stock, a unit which is accepted as being most economical both from the point of view of egg-production and the saving of labour. Although this is the main type of house, there has been a tendency in the last few years to house birds in smaller, less costly and more portable houses. In these smaller units it is easier to prevent soil contamination and to control disease.

A more recent development is the laying battery system of housing adult stock. On one holding of the Fylde 2,000 birds are housed on this system, which is spreading rapidly throughout the area.

The poultry-farmer finds excellent markets for his produce not only in the adjacent towns of Blackpool and Preston, but in the manufacturing towns of south and east Lancashire.

### STOCKING OF FARMS.

The farms are heavily stocked and a few typical examples are given below :—

#### *Farm A.*

Area : 80 acres, all grass.  
60 cows in milk.  
6 dry cows.  
15 ewes.  
200 pigs.  
1,000 hens.



*Farm B.*

Area : 210 acres, 132 acres grass, 78 acres arable.  
 65 cows in milk.  
 20 in-calf cows.  
 120 breeding ewes.

*Farm C.*

Area : 140 acres, all grass.  
 60 cows in milk.  
 25 in calf and other stock.  
 70 breeding ewes.  
 1,200 laying hens.

*Farm D.*

Area : 26 acres, all grass.  
 20 cows in milk.  
 13 other stock.  
 35 pigs.  
 20 ewes.  
 1,000 laying hens.

CROPS.

Grass is the most important crop on the Fylde farm. Heavy crops of meadow hay are produced, and the pastures carry a large number of stock. Large quantities of farmyard manure are available for dressing the meadow land, and the pasture land generally receives periodic dressings of phosphates, and frequently an early dressing of nitrogenous manure to hasten spring growth. The soil generally is deficient in lime, and the pastures and meadows receive occasional dressings of lime either in the form of cob lime or ground limestone. Hay-making commences early, usually about the first week in June. The hay is almost always carted into Dutch barns at the homestead.

The grazing season is short and as the cows have to be kept indoors for practically seven months of the year, large amounts of purchased feeding stuffs are consumed. Many Fylde farmers are wondering whether expense under this heading could not be reduced by the adoption of the method of grass drying by machinery. Hay-making in the Fylde, on account of the high rainfall, is usually a most wasteful and costly operation, and if this new method of conserving the abundant crops of grass proves economically sound it would effect a great saving in the cost of purchased feeding stuffs.

The arable land is generally farmed on the four-course system—roots, grain, seeds, grain ; although in some cases this may be modified to a three-course, cutting out one grain crop, and bringing in an extra root crop.

Oats and wheat are the common grain crops. No barley is grown. Compared with other arable areas heavy seeding of cereal crops is practised ; oats, for example, may be sown up to the rate of 3 cwts. per acre. Although some mangolds, swedes, and marrow stem kale are grown, the biggest portion of the root land is under potatoes. Eclipse is the earliest variety grown, and King Edward, Majestic and Kerr's Pink are popular second early and main crop varieties.

## HORTICULTURE.

Adjoining the seaboard there is a belt of warm, sandy loam, merging into a peaty loam, known locally as 'moss' soil. These soils are admirably adapted for the more intensive forms of horticulture, specialising in the cultivation of out-of-season salad crops and those grown under glass. The Marton district, just on the east of Blackpool, may be regarded as the centre of the glass-house industry in the county.

In this area not only is the soil suitable, but other factors, such as sunshine hours, equable atmospheric temperature, high rainfall, pure water supply and proximity to good markets, provide conditions favourable to the development of glass-house culture. This industry meets not only the local requirements of the adjacent towns, but large quantities of tomatoes, lettuce and other crops are consigned to East Lancashire and Yorkshire markets.

Most of the glass-houses in the district are of the aeroplane type, which are usually built in a series of bays measuring 15 feet to 20 feet wide, 11 feet to 12 feet to the ridge and having a height of 5 feet to 7 feet to the eaves and intermediate gutters. Some of the older houses are of the 'vinery' type, having a height of 4 feet 6 inches to the eaves and about 10 feet to the ridge. Between these two types there are numerous structures of various widths and heights adapted for the special cultures for which they are best suited.

## CROPPING SYSTEM.

The chief crops grown are tomatoes, chrysanthemums, winter and early spring lettuce, forced mint, forced bulbs, cucumbers, mustard and cress, and asparagus for foliage. While unheated houses may still be found in this district, the great majority are heated by hot water circulated on the thermosyphon principle.

During the months from March to September the houses are planted with tomatoes at the rate of 15,000 to 17,000 per glass acre. The preparation for the tomato crop is very thorough; the land is deeply cultivated, and receives a liberal dressing of strawy horse manure at the rate of 20 to 25 tons per acre, which is supplemented by generous dressings of artificial fertilisers. The average yield of tomatoes is approximately 33 tons per acre.

In a large majority of the houses the tomatoes are cleared by the middle of September, and they are again filled with winter-flowering chrysanthemums, which have been growing outside during the summer months. It is comparatively rare to find chrysanthemums grown in flower pots, but the recent introduction of open wire pots has found favour, particularly in respect to certain varieties of chrysanthemums which are bad lifters. The usual practice is to cultivate the land by mechanical cultivator after the tomatoes are cleared, and then lift the chrysanthemums by spade or fork and bring them into the houses, and plant them fairly close together in the borders previously occupied by the tomatoes. Usually 30,000 to 33,000 chrysanthemums are planted per acre.

The cultivation of the chrysanthemums out of doors during the summer to bring them to the proper stage of development to flower at the required period demands a good deal of skill and a knowledge of the special requirements of



particular varieties. Growers in this district during recent years have concentrated mainly on late December flowering varieties to meet the demands of the flower trade during the Christmas period, but many acres are devoted to earlier flowering varieties of chrysanthemums, which are marketed as cut bloom from the end of July onwards.

As a rule the chrysanthemums are cleared from the houses by the end of January, and the land is again rapidly cultivated by mechanical cultivator and prepared for a late spring lettuce crop which has been previously sown in November. Winter lettuces are usually planted at 80,000 per acre at the end of January, and are ready for marketing by the middle of March; a number of growers who do not grow chrysanthemums take two crops of lettuce off the land before it is planted with tomatoes. The cultivation of lettuces during the short days in winter demands great care and attention to cultural details, as it is the most exacting crop in the rotation. A row of early flowering sweet peas is often grown to the side of the pathway under the ridge of the aeroplane houses.

It will be appreciated that this intensive form of cultivation entails heavy labour charges, estimated at £600 to £700 per glass acre.

In certain sheltered localities cauliflowers are wintered in cool glass-houses, and in the spring are planted out in situations which are enclosed by rows of privet hedges, which provide protection against late spring frosts. By this method large numbers of cauliflowers are cut in June and early July.

Small apple orchards are found on most of the Fylde farms, and these supply the needs of the farmer's own family. While there are no specialist growers on a large scale in the Fylde, there are areas around Freckleton, Poulton-le-Fylde, Great Eccleston and parts of the Pilling district which have proved favourable for apple growing, and fairly extensive plantings of top fruit are to be found in these localities. Generally, wind and late spring frosts are the most important limiting factors in the fruit-growing districts. In recent years an effort has been made by the Lancashire Agricultural Education Committee to introduce the cultivation of black-currants as a side-line on the general farm, and demonstration areas of this crop have proved very successful.

#### EDUCATION.

Fylde farmers take full advantage of the facilities provided by the Lancashire County Council for all forms of agricultural education. The central teaching institution is at Hutton, about three miles from Preston. Courses of instruction are provided in dairying, poultry-keeping and horticulture, and there is a farm of 300 acres attached, which serves as an experimental farm and to provide milk for the Dairy School. The most recent development has been the extension of the area under glass, which now covers half-an-acre, and is designed to meet the growing needs of the glass-house industry for experimental and instructional work. Residential accommodation is provided for 30 students, and considerable extensions in the residential and laboratory accommodation are in progress. Instruction in agriculture is carried out in association with the Harris Institute, Preston. During the winter session there are usually about 60 students attending the Courses at Preston and Hutton.

Members of the staff are available not only for lectures and classes during the winter months, but to visit holdings for the purpose of giving advice on



the technical problems met with by the farmer, poultry-keeper and market-grower.

There are four successful Agricultural Discussion Societies in the Fylde, and the Young Farmers' Club movement has recently made rapid strides in the area ; about 100 heifers' calves are being reared this season by members of the clubs in the Fylde.

Instruction in manual processes is very popular, local classes being held in hedging, walling and draining.

Probably the majority of Fylde farmers visit the County Farm on the annual open day. On this occasion lecture-demonstrations are given in the various departments ; there are working demonstrations of new agricultural machinery and equipment, and a stock-judging competition for young farmers attracts competitors from all over the county. The popularity of this event is indicated by the fact that about 3,000 farmers and others interested attended the open day held last May.

The county borough of Blackpool, which includes a considerable area of agricultural land, has an arrangement with the county education authority whereby the advisory facilities provided in the county are available to residents in the borough.

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I wish to acknowledge the help given in the compilation of this article by my colleagues, Mr. G. M. Robertson, Poultry Adviser ; Mr. N. J. Macpherson, Horticultural Instructor ; and Mr. O. J. Pattison, District Agricultural Organiser.

## XII.

# TRANSPORT IN THE FYLDE BY ROAD, RAIL, SEA AND AIR

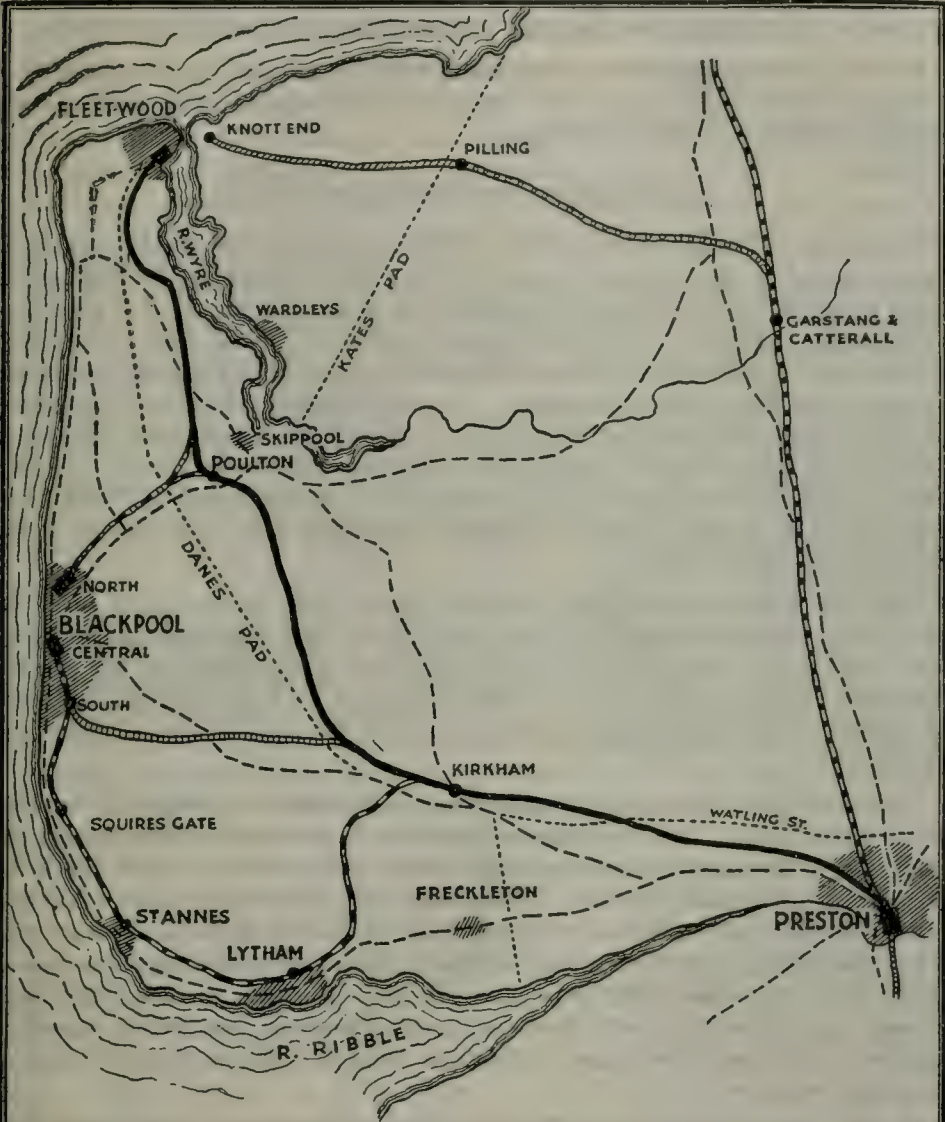
BY

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JUST over 100 years ago the coast between the Ribble and the Wyre was little more than a waste of sandhills. To-day that same coast is famous as one of England's foremost holiday centres, while at the mouth of the Wyre there has sprung up a thriving township which occupies a prominent place among our fishing ports.

What has brought about this transformation ? Little, of course, could have been achieved without natural advantages and the foresight and acumen of



REFERENCE

RAILWAYS

Year Opened

|  |                                      |      |
|--|--------------------------------------|------|
|  | North Union Railway                  | 1838 |
|  | Lancaster & Preston Junction Railway | 1840 |
|  | Preston & Wyre Railway               | 1840 |
|  | Poulton & Talbot Road Branch         | 1846 |
|  | Kirkham & Lytham Branch              | 1846 |
|  | Lytham & Blackpool Railway           | 1863 |
|  | Garstang to Pilling                  | 1870 |
|  | Pilling to Knott End                 | 1908 |
|  | Kirkham—Blackpool (New) Line         | 1903 |

Connected  
1874

ROADS

----- Modern  
- - - - - Roman

SKETCH MAP  
OF THE  
FYLDE

past and present generations of public-spirited citizens, but it may well be claimed that the development of transport, and of railway transport in particular, has played a leading part in the creation of the Fylde of to-day.

In the following pages an endeavour has been made to trace the history of transport in the Fylde area from the primitive tracks of early times to the speedy aeroplane of the present age.

### TRANSPORT IN THE PRE-RAILWAY ERA.

Remnants of a track or road made of the trunks of trees cut to a uniform length, found in the old peat beds of Pilling Moss, point to the Romans as being probably the first people to attempt the actual construction of roadways in the Fylde district. This track, known locally as 'Kate's Pad,' is believed to have been made by the Romans across the moor to link Lancashire with the Fylde *via* the Wyre ford at Poulton. Traces of Watling Street on the western side of Preston indicate that at one time a section of it ran from Ribchester to Kirkham, with branches (designated from time immemorial as the 'Dane's Pad') to the Wyre at Poulton and Fleetwood and to the Ribble at Freckleton, thus providing further evidence that there was some sort of transport in the district from early times.

After the Romans left Britain, properly made roads were a rarity until the advent and establishment of the stage coach in the late eighteenth century, and even the best of the old coach roads was very crude measured by present standards. Writing in 1770, Mr. Arthur Young ('A Tour through the North of England') gives the following description of the road between Wigan and Preston :—

'I know not in the whole language terms sufficiently expressive to describe this infernal road. Let me caution travellers to avoid it as they would the devil, for a thousand to one but they break their necks or their limbs by overthrows or breaking downs. They will meet with ruts, which I actually measured, four feet deep and floating with mud only from a wet summer. What, therefore, must it be after a winter? The only mending it receives is a tumbling in of some loose stones, which serve no other purpose but jolting the carriage in the most intolerable manner. These are not merely opinions, but facts, for I actually passed three carts broken down in this 18 miles of execrable memory.'

As this was the main road (Wigan—Preston—Lancaster), what must have been the condition of the minor roads in the Fylde? And to add to the difficulties of travellers, the highways were infested with footpads and robbers.

Stage coaches appear to have commenced serving the Fylde on August 1st, 1780, when the coach running on Mondays and Wednesdays from Manchester to Bolton, Chorley and Blackburn was extended to Blackpool. The journey from Manchester to Blackpool took the whole day, starting at 6-0 a.m., and after a change of vehicle and an interval for dinner at Preston, Blackpool was reached late the same night.

It was not until 1816 that coaches began to run with any regularity between Preston and Blackpool, and there is no certainty that this service was consistently maintained, because the Rev. Wm. Thornber, in his 'History of



Blackpool' (1837), states that the highway to Preston was unpaved, and in winter or a wet summer became almost impassable.

#### NINETY YEARS OF RAILWAY TRANSPORT (1831-1921).

The most important stage in the development of transport in the nineteenth century was undoubtedly the invention of the steam engine, which gave to the world the locomotive and the marine engine, and from about 1840 onwards the transport of passengers and merchandise rapidly reached dimensions hitherto undreamed of. It is from this period that the growth and prosperity of the Fylde dates, for the ensuing years were to see a complete change come over the face of the landscape.

The first step towards the penetration of the railways into the Fylde was the sanctioning by Parliament in 1831 of the North Union Railway, which formed an extension of the Wigan branch of the Liverpool and Manchester Railway to the town of Preston.

In 1835 the Preston and Wyre Harbour and Dock Company, formed chiefly through the efforts of Sir P. H. Fleetwood, secured the necessary Parliamentary powers to construct a railway from the terminus of the North Union Railway at Preston to Fleetwood, and to establish a harbour and docks there, from which a service of steamers could be run to Scotland and Ireland. The opening of the Preston and Wyre Railway on the 15th July, 1840, not only linked the Fylde with Preston, Manchester and many other places with railway facilities, but also brought the important Preston Market within easy reach of a large number of farms in the district for the sale of their produce.

About this time Fleetwood began to outrival its coastal neighbours, Blackpool and Lytham, as a holiday resort, and in 1844 the Preston and Wyre Railway Company, in conjunction with the Liverpool and Manchester and North Union Companies, commenced to run excursion trains to Fleetwood on Sundays during the summer months at reduced fares.

These were among the first railway excursions ever run, even if they were not the first cheap trips of any kind. In July, 1846, the whole of the 1,300 work-people of Richard Cobden visited Fleetwood by rail, and in the same month a Sunday School excursion, said to have consisted of 4,200 children and adults, arrived in Fleetwood for a day trip. In 1846 a day trip was run from Oldham, and as a special inducement it was advertised that ladies accompanied by gentlemen would be conveyed at half price. It is strongly suspected that some of the "ladies" on the train were actually members of the sterner sex masquerading in feminine garments in order to take advantage of the lower fare.

The growth of traffic on the Preston and Wyre Railway was rapid as will be seen from the following extracts from the official returns of the Company during its first five years of operation :—

|                                     | Passengers. |           | Merchandise |           | Total |
|-------------------------------------|-------------|-----------|-------------|-----------|-------|
|                                     | Number.     | Receipts. | Receipts.   | Receipts. |       |
|                                     |             | £         | £           |           | £     |
| One week ended Dec. 14th, 1842 .... | 911         | 66        | 62          |           | 128   |
| Corresponding week, 1843 ....       | 1,105       | 88        | 141         |           | 229   |
| " " 1844 ....                       | 1,601       | 139       | 164         |           | 303   |
| " " 1845 ....                       | 1,997       | 144       | 235         |           | 379   |
| " " 1846 ....                       | 2,820       | 244       | 309         |           | 553   |

In consequence of the increased traffic it was decided in 1846 to double the line, and in 1849 the undertaking was leased to the L. & Y. and L. & N.W. Companies jointly.

The year 1846 was one of outstanding importance so far as railway development in the Fylde is concerned, seeing as it did the opening for traffic of the branch line from Kirkham to Lytham in February, and another from Poulton to Blackpool (Talbot Road) on April 29th.

The advisability of connecting Lytham and Blackpool was first mooted in 1860, and the coastal railway line joining these two watering-places was opened on the 4th April, 1863—less than 75 years ago. At the time of its opening the railway consisted of a single line, seven-and-a-half miles in length, with stations at Hounds Hill (Central Station), Blackpool (South Shore) and Lytham. It had no physical connection with the line from Kirkham to Lytham, a disability which was overcome in 1874 when the Preston and Wyre Company, having taken over the Blackpool and Lytham Railway, doubled the track and installed the much-needed connection with its own system.

From this time onward the growth of the district was rapid, and its popularity as a holiday-resort, particularly for North-country people, continued to expand.

Excursion traffic became a regular feature, and to meet the ever-increasing transport demands the Railway Company expended large sums in quadrupling lines over certain sections, and re-building stations. It is worthy of note that as early as 1883 special facilities were introduced at Talbot Road Station for dealing with excursion traffic.

The effect of these developments can be traced in the growth of the population of Blackpool. In 1870 the inhabitants numbered only some 7,000 ; by 1891 the number had increased threefold to 21,000, and at the end of the next 10 years had mounted to 47,000, but by 1921 the 100,000 mark was almost within sight.

Although, strictly speaking, not lying within the area of the Fylde, the transport history of the district would not be complete without some reference to the Garstang and Knott End Railway, in view of its close association with Fleetwood.

Originally promoted with the intention of linking the L. & N.W. Railway and the market town of Garstang with the Port of Fleetwood by means of the ferry at Knott End, the portion of the Garstang and Knott End Railway between Garstang and Pilling, a distance of seven miles, was opened for merchandise in December, 1870. The promoters found themselves in difficulties at an early date. In the first place, the trains were hauled by an engine which the Company obtained on hire, and whilst this was undergoing repairs in 1872 the railway had to close down for two days. Soon afterwards the engine was seized by its owners in consequence of the hire purchase money not having been paid, and horse traction was introduced and used spasmodically during the next three years. An engine was purchased outright in February, 1875, when the line was re-opened for goods traffic, and a passenger service was instituted in May of the same year.



On July 1st, 1908, the Garstang and Knott End Railway Company was bought up by the Knott End Railway Company and the line extended a further four-and-a-quarter miles to Knott End.

#### THE LONDON MIDLAND AND SCOTTISH RAILWAY.

One result of the Railways Act of 1921 was to bring the whole of the railways serving the Fylde area under one management, namely, the London Midland and Scottish Railway. This vast organisation has done much in recent years to foster the development of the Fylde and its coastal resorts. There are few of its 2,500 passenger stations throughout the country which do not display in some prominent position a pictorial appeal to the public to visit Blackpool, Cleveleys, Lytham, St. Annes, or other places in the Fylde. Since the amalgamation of the railways much has been done, and continues to be done, to speed up traffic and to provide better comfort for passengers.

Outstanding among the many fine express trains serving Blackpool at the present time is the 'Blackpool and Fylde Coast Express,' leaving London (Euston) at 5-10 p.m. every week-day except Saturday, and arriving Blackpool (Central) at 9-53 p.m. In the reverse direction this train, which is composed of stock of the latest design, leaves Blackpool (Central) at 8-25 a.m., and reaches Euston at 12-50 p.m. The final stage of the journey of 158 miles from Crewe to Euston is run in 154 minutes at an average start to stop speed of 61.6 m.p.h.

The number of passengers reaching Blackpool and the adjacent resorts by rail now reaches the huge total of nearly six millions annually, excluding the many thousands of journeys made by season ticket holders who have taken up residence in the district. During the week preceding August Bank Holiday, 1935, the number of passengers passing through the station barriers exceeded half-a-million, while during the period of the 'Illuminations'—that is, after the normal summer season had ended—the visitors arriving by rail were in the vicinity of 750,000.

Apart from the transport of passengers, Blackpool's thousands of residents and visitors require food and the other necessities of life. To cater for the needs of the district in this respect the L.M.S. Company maintains a number of well-equipped goods stations, of which that at Blackpool is being re-built on modern lines. A comprehensive system of road collection and delivery services links these stations with the commercial and agricultural interests of the Fylde.

Kirkham (North Junction) might aptly be termed the 'hub of the Fylde,' as during a recent 24-hourly period nearly 600 trains were dealt with at the signal box there, averaging one every two-and-a-half minutes. The frequency was, of course, much higher during the peak periods, as in the early hours of the day traffic is comparatively light.

#### TRAMWAY SYSTEMS OF THE FYLDE.

The latter part of the nineteenth century saw the beginning of the tramways, which to-day afford such excellent local passenger services between Lytham and Fleetwood, following the coast for most of the distance.

Tramways commenced running in Blackpool itself in 1885, when, on the 29th September, was inaugurated what is believed to be the first electrical



tramway in this country. The trams were propelled by current conveyed to small motors from a cable concealed in a conduit in the centre of the track. Stops were numerous and sometimes prolonged, because not only was there but a single track (except on the South Beach), with loops at infrequent intervals to permit cars to pass one another, but there was a constant risk of interruption to the service through the sea or sand affecting the cable.

For the first seven years the line was leased to a private company, but was taken over by the Blackpool Corporation in 1892. The conduit system was abandoned for overhead trolley traction in 1894, and the line was extended considerably during the next few years, the Station Road tramway being opened on the 7th August, 1897, and the Promenade line extended to the Gynn in 1901.

The Blackpool and Lytham tramroad was started by a private company, with a system of gas traction. It proved unsatisfactory, and the passengers had sometimes to get out and help to push the trams up certain inclines. In 1903 the overhead electric system was adopted, and in 1920 the nine miles of track was purchased by the St. Annes Council.

The Blackpool and Fleetwood tramroad was opened on the 13th July, 1898, under powers obtained for the construction of a light railway. It has a length of 10 miles from Blackpool to Fleetwood, and is operated on the overhead trolley system. It was purchased by the Blackpool Corporation in 1919.

The tramway service operated to-day by the Blackpool Corporation is right in the forefront of modernity, and during 1935 the cars, many of them of a new and specialised design, carried over 49 million passengers. The Corporation also owns 64 motor buses, in which nearly 14½ million passengers travelled in 1935.

#### TWENTIETH CENTURY ROAD TRANSPORT.

The post-war period has been marked by the improvement and development of the internal combustion engine, and the private car and the motor bus and coach have added their quota to the volume of transport.

The district is now served by an excellent system of roads, and some idea of the extent to which these are utilised may be gathered from the figures revealed by an official census taken at key points during the 1935 August Bank Holiday period, indicating the number of vehicles entering or passing through Blackpool on the three days :—

|                  | No.    | Percentage. |
|------------------|--------|-------------|
| Motor cars       | 27,748 | 57%         |
| Motor coaches    | 4,584  | 9%          |
| Motor cycles     | 5,611  | 12%         |
| Lorries and vans | 2,407  | 5%          |
| Bicycles         | 8,258  | 17%         |
| Horse vehicles   | 136    | —           |
| Total            | 48,744 |             |

Among the many road transport undertakings serving the area may be mentioned the Ribble Motor Company, which, with its subsidiaries and

associates, connects Blackpool by express road services with 61 cities and towns as far apart as Glasgow and Edinburgh, Great Yarmouth, London and Torquay. The "Scout" Motors also provide convenient services in and around the Fylde.

#### TRANSPORT BY SEA, AND PORTS OF THE FYLDE.

The Fylde was in Roman times inhabited by the Segantii ('Dwellers of the Sea'), and there is historical support for the belief that they had a harbour or port at the mouth of the River Wyre. Since those days, however, the face of the coast has been altered by erosion, and the mouth of the river would at that time be about three miles further west than it is to-day.

For more than 200 years before Fleetwood was even imagined the River Wyre had achieved some status in the commercial world, with harbours at Wardleys and Skippool, and a Customs House at Poulton. The Lancashire historian, Baines, described Wardleys in 1825 as 'a small seaport on the River Wyre, where vessels of 300 tons register may discharge their burdens.'

Fleetwood owes its existence to a Lord of the Manor, Sir P. H. Fleetwood, who, residing at Rossall, first conceived the idea of converting a desolate warren at the northern extremity of the Fylde into a thriving seaport. He visualised a prosperous new port nearer the sea than Wardleys and Skippool, provided it could be linked by railway *via* Preston with the industrial towns of Lancashire and Yorkshire.

As previously mentioned, the Preston and Wyre Railway was opened for traffic on the 15th July, 1840, Fleetwood having started as a distinct port in 1839, with Customs established by order of the Treasury. Following the deepening of the channel by dredging, the North Lancashire Steam Navigation Company commenced operating in 1843 a steamboat service to Belfast for both passengers and cargo. Fleetwood soon became one of the principal ports of embarkation for Northern Ireland, and the excellent service to Belfast, which was subsequently run by the Railway Company's own steamers, proved highly popular, and reached very large dimensions up to the time when it was amalgamated with the Heysham service by the L.M.S. Company on the 30th April, 1928.

The originally projected regular steamer service between Fleetwood and Scotland does not appear long to have survived, even if it actually started, but it is interesting to record that on Monday, the 20th September, 1847, Her Majesty, Queen Victoria, accompanied by the Prince of Wales and the Princess Royal, landed at Fleetwood off the royal yacht, 'Victoria and Albert' from Adrossan, and completed the journey to London by rail.

Fleetwood is to-day widely recognised as an embarkation point for the two-and-a-half hours' sea journey to the Isle of Man by the royal mail steamers of the Isle of Man Steam Packet Company, which are amongst the most luxurious and fastest channel turbine steamers afloat.

The present vast industry of fishing at Fleetwood had its beginning in 1844, when the 'Fleetwood Fishing Company' purchased one of the two pilot boats (the 'Pursuit') stationed at Fleetwood, together with four more boats hired from North Meols.



By 1876 Fleetwood could boast of 84 smacks engaged in fishing, whilst to-day there are about 200 steam fishing-vessels regularly operating from the port.

The Railway Company have recognised the great possibilities of the situation of the port in relation to the fishing grounds, and its wonderful development is largely due to their foresight and enterprise. Apart from the general facilities at Fleetwood developed by the L. & N.W. and the L. & Y. Companies jointly, the L. & Y. Company many years ago provided a new dock on their Wyre Dock estate, which now, under the management of the L.M.S., is devoted exclusively to the accommodation of steam trawlers and other vessels engaged in the fishing trade.

This fish dock, which has been equipped with the latest facilities for quick handling, is among the finest of its kind now in existence, and the L.M.S. Company have not spared pains or expense in keeping it up to date. Among recent developments of note mention might be made of the new electric coaling appliances of the most modern type, which enable coal to be fed direct from railway truck into the ship's bunkers at a speed four times as great as was possible under the system of crane and bucket formerly in use.

Forty years ago the landings of fish at Fleetwood were comparatively negligible. To-day they amount to no less than 60,000 tons per annum, while the coal taken for bunkers by the fishing fleet is not far short of 400,000 tons yearly. Over 70,000 tons of ice are also taken on board the fishing boats annually, whilst another 15,000 tons is required by the traders for the purpose of packing the fish for despatch by rail. In the early days of the port all the ice used at Fleetwood was imported from Norway, but this has been completely displaced by ice produced on the Dock Estate itself, the Fylde Ice and Cold Storage Company having built a well-equipped factory immediately adjoining the fish dock. The daily output from this factory is about 400 tons of crushed ice. It is delivered to the fish market and on board the trawlers by means of shoots, thereby obviating handling.

The trawling industry does not, however, exhaust the possibilities of Fleetwood as a port, ample facilities being also available for the general cargo trade, both at Fleetwood itself and in the Wyre Docks.

#### STEAMBOAT EXCURSIONS FROM BLACKPOOL.

There is not sufficient water at any one of Blackpool's piers at low tide for vessels of large draught, but a number of pleasure steamers ply to various destinations during the holiday season.

Blackpool's first steamboat was the 'Wellington' in 1871, followed in 1879 by the 'Bickerstaffe.' In 1895, these two boats were supplemented by two new cross-Channel boats, the 'Queen of the North,' owned by the Blackpool Steam Ship Company, operating from the Central Pier, and the 'Greyhound,' owned by the North Pier Steam Ship Company. Eventually these two concerns amalgamated. There is now only one excursion steamer in regular use during the summer, and this operates from the North Pier.

#### THE PORT OF PRESTON.

The town of Preston is situated on the River Ribble, 15 miles from the sea, and lies at the south-eastern corner of the Fylde. For many years it was the



main focus point of all descriptions of traffic into and out of the Fylde, and its market was the magnet which attracted the produce of the Fylde.

In its early days the River Ribble was an uncontrolled waterway wandering out to sea on an ever-changing course, rendering navigation very precarious. Moreover, the river was a source of potential destruction to the land through which it flowed, and it is not, therefore, surprising to find that the first efforts to obtain some control over the waters were made by the riparian landowners who were seriously affected by its sudden changes of course.

A company was formed in 1806 to provide funds for the building of training walls on the banks of the river for a few miles towards the sea. Owing to the limited capital available, the results were somewhat unsatisfactory, and the company sought further borrowing powers in 1830, with the object of extending the sea walls still further towards the sea. As a result of the stabilising of the river channel within the length of the new walls, the trade passing on the river began to improve, and it was decided in 1838 to form a joint stock company known as the Ribble Navigation Company, to carry out certain further improvements to stimulate trade on the river.

There was at this time no dock at Preston, and vessels, which were necessarily of shallow draught, had to lie at a short quay in the tidal river. In 1845 the Ribble Navigation Company and the North Union Railway Company jointly constructed a branch railway from the quay to the main line running through the town. This branch is known as the Ribble Branch Railway, and is still jointly controlled. In 1883 the Corporation of Preston finally secured full control of the Navigation undertaking, and it was decided to divert the river and to build a 40-acre dock on the old bed and the adjoining land. The foundation stone of the dock was laid on the 16th July, 1885, by H.R.H. the Prince of Wales (afterwards King Edward VII.), and the dock was finally opened for traffic on the 25th June, 1892, by the Duke of Edinburgh.

The equipment has been modernised from time to time to keep pace with requirements, thereby affording excellent facilities for the rapid handling of merchandise from ships to railway wagons alongside, and since the Corporation took it over in 1883 the history of the dock has been one of continual growth and expansion.

#### AIR TRANSPORT.

The Fylde, represented by Blackpool, has always been in the forefront of aviation, and it was towards the end of the 1909 season that Lord Northcliffe suggested Blackpool should have an aviation week. This idea was received with much enthusiasm. After preliminary enquiries at Rheims, where France was holding its aviation 'premiere,' a deputation was sent from Blackpool to that town to ensure the presence of the leading Continental aviators at Blackpool for what was hoped to be Britain's first aviation week. Actually, however, Doncaster stole a three days' march on Blackpool on this occasion, and commenced their meeting on October 15th, 1909; but it can be claimed that Blackpool's aviation week, which began on October 18th, was on a larger scale, and included in its programme such world-famed pilots as Hubert Latham, Henry Farman, Paulhan and Leblanc, who were at that time making flying history.

Unfortunately, this first aviation week was not favoured with good weather, and consequently there was little actual flying.

The venture was, however, repeated the following year, under the auspices of the Lancashire Aero Club, and proved most successful. This second meeting lasted from July 28th to August 20th, 1910, and on Monday, 10th August, at 4-0 p.m., M. Tetard, a French pilot, flew round the Tower. This was the first occasion upon which it had been encircled by an aeroplane, though an airship piloted by Captain Spencer is stated to have circumnavigated the Tower when it flew over Blackpool on October 20th, 1902.

Having so early demonstrated a strong faith in the future of aeronautics, it is only fitting that Blackpool should to-day possess two airports which link it by regular air services with the Isle of Man, Liverpool, Manchester, London, Glasgow and Belfast. One of these airports belongs to the municipality, and is located at Stanley Park, only one-and-a-half miles from the centre of the town. It is thus most conveniently situated, and is complete with Customs clearance facilities and fine club-house.

Planes belonging to British Airways, Ltd., leave the airport at regular intervals for the Isle of Man, Belfast, Glasgow, London, etc. The first air service between Blackpool and the Isle of Man was made from the Stanley Park Aerodrome by an amphibian machine on March 25th, 1932, the journey to the Island taking 40 minutes.

In April, 1933, the Blackpool and West Coast Air Services brought into use their aerodrome at Squires Gate on the site of the old racecourse, conveniently situated immediately to the landward side of the L.M.S. Company's Squires Gate Railway Station. At first no regular services were run, but planes could be chartered as required. On July 1st, 1933, however, the Blackpool and West Coast Company commenced a regular service to the Isle of Man, with connections to Belfast and other places.

Railway Air Services, Ltd. (an organisation created by the four Main Line Railways) have, in collaboration with the Isle of Man Steam Packet Company, formed a section designated 'The Manx Airway,' which commenced operating from the Squires Gate Aerodrome on the 17th April, 1935. By this collaboration air passengers to the Isle of Man are afforded the various luggage-in-advance arrangements familiar to passengers by railway and steamer. Subject to certain regulations, they are also enabled, having booked by air, to return by surface transport or *vice versa*, according to their choice. Connecting air services are run daily from Blackpool to Manchester, Liverpool and, except on Sundays, Birmingham and Croydon.

Not only are passengers carried by air from Blackpool to the Isle of Man, but the newspaper proprietors also take advantage of the speedy service to get the printed news on the breakfast table of the early-rising visitor to Mona's Isle.

The average journey time from Blackpool to the Island is about 40 minutes, but, helped by a strong following wind, one of the machines last year completed the trip in 29 minutes. Another notable record was from Liverpool to Blackpool in 13 minutes. A striking contrast to the journey by coach 150 years ago !



## IN CONCLUSION.

Thus has the growth and development of the Fylde been closely associated with railway enterprise, while in later years both road and air transport have arrived to add to the amenities of a district already famed for the wealth of its attractions.

Apart from the business of carrying the huge throngs who annually visit Blackpool and its neighbouring towns on holiday bent, modern transport brings within reach of the visitor the Lake District and other beauty spots, thus, so to speak, providing a scenic background for those who wish to combine the bracing air and unlimited entertainment of the coastal resorts with the simple grandeur of mountain, lake, and stream.

If transport has helped the Fylde, so also has the Fylde aided transport, for, backed by a vigorous and progressive policy, the district has earned a reputation national in character which draws the visitor over the length and breadth of the land. Let transport, therefore, in whatever form, live up to this epic of local achievement which it has itself assisted to create.

## XIII.

## THE LANCASHIRE SEA FISHERIES

BY

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A SPIRIT of adventure can be detected as a persistent and important factor in the growth of the Lancashire Sea Fisheries. The almost enclosed epeiric basin, known as the Irish Sea, is virtually an enormous fish pond, on the shores of which the Lancashire Sea Fisheries have become the most important, with Fleetwood as the third principal port in England and Wales for fish landings. It is probable that the ascendancy of the Lancashire fisheries is due to the following main natural or historical causes :—the extent and configuration of the bed of the Irish Sea, with the partly correlated tidal currents and drifts, the existence of navigable and protected estuaries on the Lancashire shores, the proximity of a large industrial area, including coal mining, the development of steam engines in fishing vessels, for fishing gear and for land transport, and the existence of a spirit of enterprise and adventure amongst the sea-faring population and others associated with the fisheries.

The bed of the Irish Sea is characterised on the western side by a deep channel with a depth of 50 to 90 fathoms, extending from the St. George's



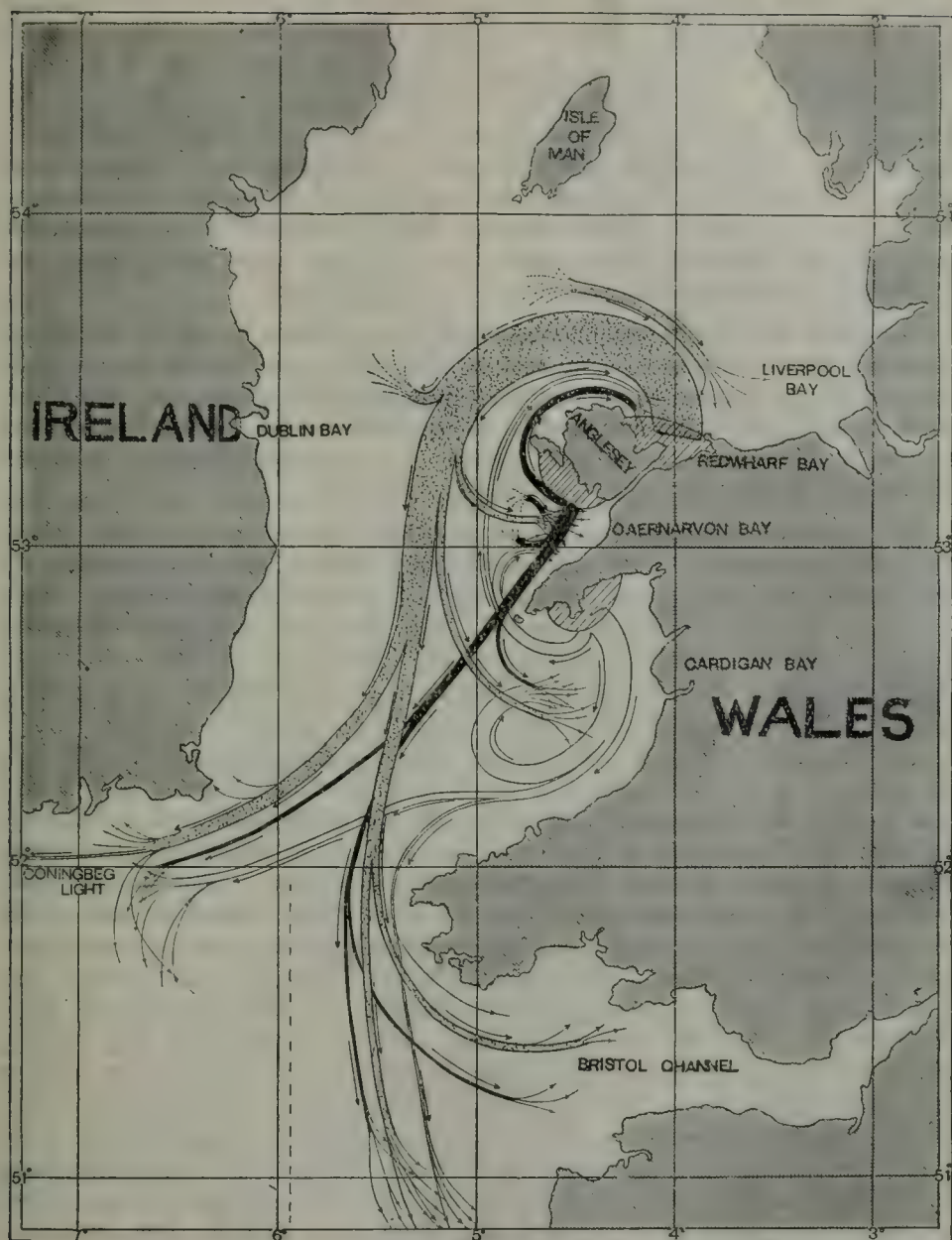
Channel in the South to the North Channel between Ireland and south-west Scotland, where greater depths to 149 fathoms occur, and on the eastern side by a shallower, shelving, sandy bottom decreasing in depth shorewards from about 20 fathoms off the Isle of Man.

The sea is large enough to maintain its own fish population, of which plaice, dabs, skates and rays, gurnards, flounders and the sole are mostly resident and are commercially important. Other fishes invade the Irish Sea for feeding or spawning, such as hake, cod, haddock, whiting, mackerel, sea-perch, grey mullet and herring, possibly some plaice and sole, and provide valuable fisheries. The shallow waters and extensive foreshores of sand on the east make excellent rearing grounds for those forms of life on which fish food, *i.e.*, small fishes, bivalves, crustaceans and worms, thrive, while the foreshores are suitable for the support of vast numbers of cockles and mussels and other molluscs.

The propinquity of abundance of fish off the Lancashire coast with a large industrial population inland and near is linked by the development of a hardy race of fishermen. Some thousand sailing craft of various sizes, including about 120 of first-class standard, fished from the Lancashire ports in the early '90's, and landed about 57,000 cwts. of fish annually. But about this time steam-trawlers, *viz.* : boats propelled by steam and using the new otter trawl, which could be worked by machinery, arrived in small numbers, and the annual catch rose to 239,000 cwts. in 1900. From about that time steam-trawlers have increased in dimensions and numbers to a total of 146, while the sailing-vessels have gradually become reduced at the present day to three smacks fitted with auxiliary motors, with some 13 small motor-vessels filling in part of the gap in the inshore fishing left by the withdrawal of the larger sailing-vessels.

Last year (1935) the total landings of wet fish amounted to one-and-a-quarter million cwts., chiefly at Fleetwood, whence about 36 per cent. was dispatched to London, 9 per cent. to Manchester, 9 per cent. to Liverpool, 5 per cent. to Birmingham, and the balance to the northern counties and more distant places. Thus the Lancashire fisheries are now supplying far more fish than is demanded in the immediate neighbourhood. This rapid expansion has been rendered possible by general improvements for equipping fishing vessels, and the development by the London, Midland and Scottish Railway Company of facilities for expeditious landing and treatment of fish and its dispatch from Fleetwood. The old timber pond was converted into a spacious and well-equipped dock with three cranes of the cantilever type capable of delivering 50 tons of coal per hour, and recently two electric belt conveyors have been erected, each having a capacity of 200 tons per hour, and four more are to be provided. At the present time the trawlers consume some 400,000 tons of coal annually, which is derived mostly from the Lancashire and Yorkshire coal-fields.

The modern trawler can nowadays discharge the catch directly on to the quay-side, where it is sorted into boxes in the early morning hours, ready for auctioning at 8-30 a.m. in the contiguous fish market. The general organisation is so efficient as to enable the frequent daily dispatch by rail of 500 tons of fresh fish. For the preservation of fresh fish ice is consumed by the steam-



Schematic representation of the general movements in the sea of marked plaice liberated off the shores of N.W. Wales in the areas indicated by shading. The widths of the tracks are proportional to the number of plaice taking part in the subsequent movements.

(From Report by R. J. Daniel and R. A. Fleming, *Lancashire Sea-Fisheries Report for 1932.*)



trawlers at the rate of 80,000 tons, and by the fish merchants 20,000 tons annually, and is produced on the ammonia flooded system by the Fylde Ice and Cold Storage Co., by modern machinery. The ice factory can produce 600 tons of ice daily, and has storage capacity for 8,000 tons. The ice is manufactured in 2 cwt. blocks, which are delivered by gravity chutes to the dock sides, and can be crushed at the rate of one ton per minute for delivery to the ships. Other ancillary activities are the manufacture of fish meal and fish oils, engineering, ship-repairing, trawl-net and box-making industries, and provisioning stores. Establishments have also arisen for the curing and preparation of dried salt fish in which there is a large export trade, as well as a school for instruction in navigation and engineering.

The scene on the fish market from 8-30 a.m. to noon is one of very great interest ; the bewildering auctioning is followed by entertaining feats of skill and rapidity in preparing the flesh of certain fishes for the market, while the adjacent ice factory<sup>1</sup> and the modern steam-trawler, with its wireless, depth-recording, direction-finding and fishing gear equipment, afford excellent illustrations of the application of science to industry.

The character of the off-shore fishery is given by the amounts of the different kinds of fishes landed. Last year, in the whole of the Lancashire and Western area, which includes Cheshire and North Wales, the following weights of the commoner fish in cwts. were landed : cod (including codling), 182,131 ; haddock, 167,321 ; hake, 141,296 ; skates and rays, 102,950 ; herrings, 76,455 ; whiting, 44,881 ; plaice, 32,203 ; mackerel, 23,651 ; soles, 8,406 ; dabs, 3,308. An important feature among these figures is the well-known decline in landings of hake, a fish whose value has enhanced greatly in the last 20 years and is now the subject of much concern. There seems little doubt that this fish has been greatly reduced on the fishing grounds by over-fishing, and that care is required in the future interests of the fishery in maintaining adequate stocks in the sea. A certain quantity of hake is taken in the Irish Sea, including young ones which feed and grow there, and other fish which enter the sea in summer for feeding, after spawning in deep water ; most of the hake are, however, taken in the period February-March to July-August in the East Atlantic, mainly near the continental edge (about 100 fathoms) and often at depths of 150 to 300 fathoms or more. In this period there is a curious tendency for maximum landings about the time of full moon. The decline in recent catches led to the Fleetwood trawler owners combining with the Development Commission to carry out two exploratory voyages with a view to the discovery of new hake-fishing grounds. The results were satisfactory in that good catches of fish were made and new grounds opened up. These grounds have since been successfully fished commercially, but the hake deficiency problem remains as yet unsolved.<sup>2</sup>

Cod, haddock, ling and coalfish are also taken in voyages to the Atlantic near the 100-fathom line from the north-west of Ireland to the north-west of Scotland. Regular visits are made to different regions off Iceland also for cod, haddock, plaice, halibut, lemon soles, catfish and coalfish chiefly. Nearer

<sup>1</sup> The Fylde Ice and Cold Storage Co. cordially invite British Association visitors to inspect the ice factory.

<sup>2</sup> See Buckland Lectures by C. F. Hickling on *The Hake and the Hake Fishery*, 1935.



home, in the eastern part of the Irish Sea and in the Welsh bays, regular fishing produces mostly cod, plaice, whiting, skates and rays, some soles and bass. Herring and mackerel are for the most part taken in the trawl in the summer months off Donegal, and in late summer and autumn off the north of Ireland and the west of Scotland. Herrings also enter the Irish Sea to spawn off the Isle of Man regularly in summer, and in Cardigan Bay in winter, and are taken in autumn in the Solway Firth. There are thus at least summer and winter spawning herrings in the Irish Sea. Only a small proportion of these, which are caught in drift nets, are landed in Lancashire.

Notwithstanding the landing of one-and-a-quarter million cwts. of fish at the Lancashire ports, an addition of 15 new steam-trawlers at a reported cost of £25,000 each to the Fleetwood fleet is announced to take place this summer. The new boats will be equipped for fishing at great distances, and are anticipated to increase the landings of fish and subsidiary industries and employments ashore.

The inshore fisheries have steadily declined as the steam-trawlers have increased in numbers, so that the total landings at the minor ports in the district last year was only 11,873 cwts. Plaice, dabs, flounders, rays and whiting constitute the greater part of the fish catch. Prawns and shrimps yield valuable fisheries off the North Lancashire coast and in the estuaries, some 11,500 cwts. being landed last year at a value of about £20,000. In the absence of rocky ground off the Lancashire coast, crab and lobster takings are negligible; and native oysters do not apparently now exist nearer than Solway Firth. Other shell-fish, *i.e.*, mussels and cockles, are taken in great abundance on the extensive sandy shores, and form important inshore fisheries. Last year about 50,000 cwts. of mussels and 11,500 cwts. of cockles were collected in the district, but these yields are small in comparison with former times; for example, in 1911 about 74,000 cwts. of mussels and 65,500 cwts. of cockles were taken. The shell-fisheries are liable to fluctuations over a long period, and times of plenty and scarcity are a common feature of their history.

The Lancashire Sea Fisheries are unique in respect of the scientific interest taken in them by the local District Fishery Committee, which is normally composed of laymen. Soon after the Lancashire Sea Fisheries Committee was formed, in the '90's, with Mr. John Fell, the first Chairman, and Mr. Robert Dawson, Superintendent, scientific investigation was begun, and continued actively for more than 40 years. Two laboratories were established, one at Piel and one in the University of Liverpool. Professor Herdman was given charge of the fishery investigations, with Andrew Scott and James Johnstone as assistants. These men laid the foundation of scientific fishery knowledge appertaining to the Irish Sea area. The life-histories and migrations of fishes (see Fig. 1) were investigated in relation to tidal currents and sea-temperature, data regarding which were accumulated in special researches. Important contributions on the habits, growth, food, parasites, diseased conditions, structure, seasonal change in food values and general biology of fishes, shell-fish culture and the scientific aspect of the general economy of life in the sea, were made. Extensive fishery statistical work, much of which was helpful in drafting necessary fishery regulations, and general planktonic and faunistic besides other scientific investigations were carried

out and recorded in annual and other reports. The Quarterly Reports of the present Superintendent, Dr. J. T. Jenkins, also abound in valuable practical fishery information. Not content with scientific investigation, the Committee, in collaboration with the Lancashire Education Committee, organised courses of instruction in biology for fishermen in the laboratory at Piel, and later instituted successful courses in navigation and seamanship for fishermen. From these activities, Dr. and later Professor James Johnstone emerged as one of the most distinguished of British marine biologists. With the growth of the population the modern problem of the effect of sewage pollution on shell-fish was early experienced, and investigated by the local Committee, with the help of Professors Herdman and Boyce and Dr. J. Johnstone.<sup>3</sup>

A new station has recently been constructed at Lytham, near Blackpool, by the Lancashire County Council, for the self-cleansing of unclean mussels, so that the local fishermen will now be able to market a commodity which would otherwise be unsaleable for human consumption. At the present time the Lancashire Sea Fisheries Committee is showing special activity in helping to develop and prevent further deterioration of the inshore fisheries, which produce a type of man unsurpassed in any other occupation.

The advance of the Lancashire Sea Fisheries may be largely due to natural causes, but these have been exploited by a competent body of vigorous fishermen, far-seeing commercial bodies—amongst whom the railway company is an important one—and the Lancashire Sea Fisheries Committee, assisted by distinguished laymen and scientists. Co-operation of the Fleetwood fishery vessel owners, of the wholesale buyers (as the Fleetwood Fish Merchants' Association) and of the inshore fishermen in fishermen's co-operative societies under the Fisheries Organisation Society has also played an important part in the success attained.

<sup>3</sup> Dr. Johnstone made a special study of the self-cleansing of sewage-polluted mussels, which was followed later by extensive experiments by Dr. R. W. Dodgson at the Conway Station of the Ministry of Agriculture and Fisheries and the development there of an ingenious and successful commercial self-cleansing process. (See *Ministry of Agriculture and Fisheries, Scientific Investigations, Series II., Vol. X., No. 1, 1928, Report on Mussel Purification.*) The principle of this process is now applied to the cleansing, also, of oysters.

#### XIV.

## THE GROWTH OF BLACKPOOL AS A HEALTH AND HOLIDAY RESORT

BY

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SECOND MASTER, BLACKPOOL GRAMMAR SCHOOL.

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THE Borough of Blackpool was constituted in 1876 out of the whole of Layton-with-Warbreck together with part of Bispham-with-Norbreck and part of Marton. Since that date the Borough has extended its boundaries three times.



In 1879 more of Marton was added. In 1917 the remainder of Bispham and part of Carleton and, in 1934, the remainder of Marton and parts of Carleton and Hardhorn were also added.

The remarkable growth of Blackpool in the last hundred years is illustrated by the following figures :—

## GROWTH OF BLACKPOOL SINCE 1800.

|           | Population.              |                                | Rates.                    |                      |
|-----------|--------------------------|--------------------------------|---------------------------|----------------------|
|           | Borough of<br>Blackpool. | Layton-with-<br>Warbreck       | Number of<br>Assessments. | Rateable Value.<br>£ |
| 1801 .... | —                        | 473                            | —                         | —                    |
| 1811 .... | —                        | 580                            | —                         | —                    |
| 1821 .... | —                        | 749                            | —                         | —                    |
| 1831 .... | —                        | 943                            | —                         | —                    |
| 1841 .... | —                        | 1,968                          | 201                       | —                    |
| 1851 .... | —                        | 2,564                          | —                         | —                    |
| 1861 .... | —                        | 3,907                          | 928                       | —                    |
| 1871 .... | —                        | 7,092                          | 1,774                     | —                    |
| 1881 .... | 14,229                   | 12,711                         | 4,138                     | 104,709              |
| 1891 .... | 23,846                   | 21,970                         | 6,436                     | 178,377              |
| 1901 .... | 47,348                   | —                              | 13,187                    | 427,938              |
| 1911 .... | 58,371                   | —                              | 16,914                    | 532,177              |
| 1921 .... | 99,640                   | —                              | 21,464                    | 817,556              |
| 1931 .... | 101,553                  | —                              | 33,561                    | 1,308,758            |
| 1932 .... | 104,100                  | (Registrar General's estimate) |                           | 1,322,678            |
| 1933 .... | 104,100                  | ”                              | ”                         | 1,347,380            |
| 1934 .... | 109,850                  | ”                              | ”                         | 1,432,240            |
| 1935 .... | 120,200                  | ”                              | ”                         | 1,530,769            |
| 1936 .... | 125,000 (Estimated)      | —                              | —                         | 1,574,063            |

Scarcely anything is recorded of the History of Blackpool before the seventeenth century. While Marton (Mereton), Layton-with-Warbreck (Laton) and Bispham (Biscopham) were mentioned in the Domesday Survey, the first reference to Blackpool in any record does not occur until 1602, when 'Ellen, daughter of Thomas Cowban de Blackpoole' was christened at Bispham Parish Church. Saxton's map of 1577, the first engraved map of Lancashire, marks Rosso Hall, Thornton Hall, Byspam in ye Fyle, Stanyng, Laton, Poton, Marton and Marton Mere, but does not include Blackpool. A map of Lancashire, 'performed by John Speed' in 1610, has the same omission. A chart of Morecambe Bay, however, surveyed in 1736-7 by Samuel Fearon and Inigo Eyes, marks the following :—Warbreck, Warbreck Gin, Little Bispham, The Red Bank, Fox Hall, The Black Pool, and Blackpool Town. Until the seventeenth century Blackpool was only a strip of land along the sea shore with a few small farm houses and isolated cottages some distance from the sea. Blackpool has never been a fishing village. On the contrary its history has been entirely that of a seaside health and pleasure resort.

Towards the end of the seventeenth century Edward Tyldesley, of Myerscough Lodge, married a daughter of Sir Thomas Fleetwood, Lord of the Manors of Bispham-with-Norbreck and Layton-with-Warbreck, and built a seaside resort called Vauxhall on land owned by his father-in-law. Later it



became an inn, known as the Fox Hall, catering especially for the annual horse races on Layton Hawes.

The early eighteenth century saw the rapid development of many seaside resorts when the 'seaside recess' became fashionable. Visitors soon began to arrive on this coast, and in 1735, Ethart a Whiteside adapted his cottage to lodge some of them. This cottage, a small dwelling covered in straw thatch, was situated in the fields now occupied by General Street. Richard Pococke (1704-1765), who became Bishop of Meath in 1765, visited Lancashire between 1753 and 1754, and has recorded that 'At Blackpool, near the sea, are accommodations for people who come to bathe.' In 1769, the whole hamlet contained only 28 houses, four of which had slate roofs, but three inns had been built. Of these Bonny's (originally known as Old Marjory's) charged 10d. a day, and the Old Gynn Inn 8d. a day. The third, a small inn on the site of the present Clifton Hotel, was the first in Blackpool. A cottage at the Lane Ends also catered for visitors. The Gynn Inn was built at the side of the creek marked in the 1738 chart of Morecambe Bay as Warbreck Gin.

Thornber, in his History of Blackpool published in 1837, states 'The houses (in 1769) were few and scattered ; from the Church (St. John's Parish Church) to the sea a small white cottage stood, a solitary dwelling (on the site of the Albion Hotel). From the hovel standing on the site of Bennett's Hotel to Fumbler's Hill (the vicinity of the Cocker Street Baths) eight cottages might be numbered, all of these, with the exception of Forshaw's Hotel, merely huts ; and at the lower end of Blackpool were eighteen battered dwellings many of which are now washed down and the others dilapidated. These composed the village.' He adds that by 1790 many improvements had been made. 'Several commodious licensed resorts (we dare not as yet dignify them with the title of hotels) had risen up and the hamlet before scattered was assuming a more compact appearance . . . . . Small as the village was and notwithstanding its humble conveniences, during the summer months an overflowing company constantly flocked to it ; barns and stables afforded a nightly shelter to the poorer class of individuals. Indeed, the visitor of rank and property deemed himself fortunate in securing a clean bed in a thatched cottage and was content with an humble pallet under a roof of straw in an apartment occupied by the family. Old people love to recall how the late Sir Robert Peel and his son, the now distinguished statesman, took up their abode in the cottage now occupied by John Parr.'

Before the end of the century Blackpool was being advertised in the Press. In 1783, the 'Manchester Mercury' announced that the Manchester to Blackpool coach would begin to run on Monday, June 9th, and every morning except Sunday at 6-0 o'clock throughout the bathing season. The inside fare was 14s. A Halifax to Blackpool coach service on three days a week was established in 1782, and was announced as for the Blackpool season. The Post Diligence left Halifax at 5-0 a.m., and the single fare was 18s. 6d. By the early years of the nineteenth century a regular coach service from all parts of Lancashire had been organised. In the 'Manchester Mercury' also, Lawrence Bailey announced that he had 'completely furnished and fitted up a commodious genteel house in an eligible situation. A bathing machine will be kept for the use of friends.' In 1787, John Bonny also advertised that he had

built 'a large dining room with lodging for twenty beds.' His terms were 2s. 2d. per day for ladies and gentlemen, and 1s. 6d. per day for children and servants.

By the end of the eighteenth century Blackpool had already achieved fame as a health and holiday resort. In 1788, the Birmingham bookseller, William Hutton, published his 'Description of Blackpool in Lancashire, frequented for Sea Bathing.' In that year, according to Hutton, the number of visitors in August was about 400. The chief houses and farms had been enlarged and had become inns or coffee houses. The number of habitations had increased to 50 and these were spread over the space of one mile. Four additional inns had been built, Bailey's (now the Metropole), Forshaw's (the Clifton), Hull's (the Royal) and The Yorkshire House (the York Hotel). A promenade six yards wide and 200 yards long had been constructed between the Lane Ends (the County) and the Clifton Hotels.

Hutton describes at some length the amusements to be enjoyed. Visitors might 'Ride or walk on the sands or the parade, or the pretty grass walk on the fringe of the sea bank.' There were bowling greens, boats for sailing and butts for bow shooting. Excursions were arranged for visits to the Number 3 Hotel, where the gardens and bowling greens were popular. There was also in the summer months a theatre, though for nine months in the year it was the threshing floor of a barn. It was fitted with rows of benches divided into 'pit' and 'gallery' and the charges were 2s. and 1s. The total takings for a full house were £6.

In 1790, some verses left by a visitor enumerate the hotels and lodgings from south to north and give the following list :— Mr. Bonny's, Mr. Hull's, Mr. Hudson's, Bailey's (site of Metropole Hotel) :

'The next house is Bailey's so new and so neat,  
Much pains he has taken to make it complete.  
It stands on the beach far detached from the rest,  
And with a fine spring of good water is bless'd.'

Old Ned and Old Nanny at Fumbler's Hill and The Gin complete the list. The space between Fumbler's Hill (the neighbourhood of Cocker Street) and the Gynn remained without houses until 1846.

Between Hutton's visit and 1801, fifty new houses were built in four groups : the most northerly group at Fumbler's Hill ; further south a group near and including the site of the County Hotel ; a third in the locality of the Royal Hotel and the most southerly in the vicinity of Foxhall. South Shore remained quite undeveloped until the eighteen-twenties. Most of this area consisted of the 'Waste or common called Layton Hawes, which had been enclosed in 1767. In 1800, then, the whole hamlet was contained between Fumbler's Hill to the north (excluding the Gynn) and the ruins of Foxhall to the south, and boasted five good-class hotels. (Porter. 'History of the Fylde of Lancashire.')

The first years of the nineteenth century saw a more rapid expansion in the growth of Blackpool. Much of this was due to the enterprise of the Banks brothers, the memory of whose services is perpetuated in the Arms of Blackpool by the inclusion of the fleur-de-lys. Henry (1759-1847) and Thomas (b. 1762), became tenants of the coffee house at the corner of Lane Ends. The owner was William Yates, of Oswaldtwistle, partner of Robert Peel, who started calico



printing and later introduced Hargreaves's Spinning Jenny at Brookside, Oswaldtwistle. William Yates later was partner and father-in-law of the first Sir Robert Peel. Henry Banks bought from William Yates the estate which extended from Church Street to the Royal Hotel and as far inland as Regent Road. He rebuilt the Hotel, erected a number of houses and a distinct hamlet arose extending from the sea front to Temple Street, St. Ann's Street and the site of the Grand Theatre.

Gradually the four groups were linked up. In 1811, the number of houses was 113, and these had increased to 148 by 1821. In that year, Henry Banks constructed a hulking and cobbled sea fence from the Royal Hotel to the Clifton.

Between 1821 and 1851 the rate of expansion was more rapid still. In 1827 there was an exceptionally prosperous season and the overcrowding of accommodation stimulated further building. In 1830, Mr. Whittle<sup>1</sup> calculated that 'at the flux of the season there were between 800 and 1,000 visitors.' By 1831, the number of houses had increased to 187. Thornber ascribes the increased popularity of Blackpool at this time to the fact that, in spite of the great inrush of visitors from infected areas, Blackpool avoided the cholera epidemic of 1832.

The year 1836 saw great improvements. Shops increased in number, cottages were constructed 'on modern principles,' public baths were erected on the beach adjoining the Lane Ends Hotel and 200 beds were added to the existing accommodation. In 1837 the Victoria Terrace and Promenade were erected. These consisted of seven shops and above them a Promenade 32 yards long which opened through folding windows upon a balcony six feet wide. Attached were a news room, library and billiard table. About this time, too, was erected Hygiene Terrace on the site of the present Palace Theatre buildings. By 1841, the number of houses was 305.

This rapid development, which was accelerated by the opening of the railway from Preston to Poulton and Fleetwood in 1840, and to Blackpool and Lytham in 1846, brought with it urgent problems of local government administration. There was a scarcity of fresh water. The few pumps that existed were kept locked and the users charged heavily for supplies. Water was also brought from Marton Mere and retailed in barrels and tubs from carts. The inevitable consequence was severe epidemics from time to time, including typhoid. The only sewer was the one laid by Henry Banks. By 1849 the number of houses was 421, and in that year the number of births was 64 and of deaths, 74. It is not surprising, therefore, that a Petition was sent in 1849, to the newly-created General Board of Health, and on October 23rd, 1851, Layton-with-Warbreck was constituted a Local Board of Health. The name was changed to the Blackpool Local Board of Health District on July 31st, 1868.

In 1853, in the first year of office of the new commissioners, the First Improvement Act, the forerunner of 16 other Improvement Acts, gave Parliamentary sanction to the Local Board to regulate street-making, building, sanitation, the proper lighting of the Promenade and town by gas, and the sale of marketable goods. This marks the beginning of that administrative efficiency without which Blackpool could never have attained its present popularity. From this time, Blackpool quickly began to assume its present outline. South

<sup>1</sup> His book, 'Marina,' is quoted in Porter's 'History of the Fylde.'



Shore was rapidly developed. Talbot Road was opened out and the lower end formed into a spacious square. Several hotels and large houses were built. Carlton Terrace was built in 1863, and Claremont Park begun in the same year. In 1867, the Prince of Wales' Arcade in Central Beach was opened, and in 1868, the Arcade and Assembly Rooms in Talbot Square.

In 1863 the Local Board took over from the lessee the gas undertaking, which for some years had been a losing concern. From the beginning a profit was made, and since that date to March, 1936, the total net profit has amounted to £627,683, £382,271 of which has been contributed to rate relief and £124,111 to 'other purposes.' These include amounts assigned to annual Fetes, from 1878 to 1882, inclusive; decorating the Parade and the Battle of Flowers, from 1889 to 1892; the Agricultural Shows of 1883, 1884 and 1894; the purchase of pictures for the Art Gallery, and the Autumn Illuminations.

The Second Improvement Act, 1865, empowered the Local Board to undertake the construction of a new promenade and carriage way from Carlton Terrace to South Shore. Two applications had to be made. The first failed because the expenses were to be borne by the whole body of the ratepayers. The second succeeded because the Bill empowered the Local Authority to levy tolls for the use of the Promenade. This power was not intended to be, and never has been put into force. This will readily be understood by all who have seen the Blackpool Promenade on any recent Bank Holiday. The Promenade and carriage way was constructed from Cocker Street to Dean Street at a cost of £88,000. It was opened on Easter Monday, 1870, by Colonel Wilson-Patten, M.P. for North Lancashire (afterwards Lord Winmarleigh).

Blackpool celebrates this year the Diamond Jubilee of the Charter of Incorporation, which was granted on January 21st, 1876. The Charter Mayor was Alderman William Henry Cocker, who shares with Henry Banks the position at the head of the list of those entitled to be called 'Makers of Blackpool.' The Memorial in Stanley Park commemorates his services to the town, which are also honoured by the inclusion of the lion in the Arms of the Borough. The population in 1876 has been estimated at approximately 10,000. The rateable value was £76,838 and a penny rate produced £279. Dr. Cocker's most famous achievement was undoubtedly the State Visit in 1878, of the Lord Mayor of London, the Sheriff of Middlesex, the Lord Mayors and Mayors of fifty cities and towns of the North and Midlands, together with their ladies, for the opening of the Winter Gardens. They were entertained for a week at the Hotel Metropole, a public subscription being raised for the purpose. This was a most effective piece of publicity and set the high standard in the art of advertising which Blackpool has ever since been obliged to maintain in a world of increasing competition.

The necessity for advertising was soon grasped, and in 1879, the Third Improvement Act gave the new borough a unique privilege, repeatedly denied to rival resorts, which has since enabled her to levy annually a twopenny rate for advertising purposes.

The Promenade Tramway, which Blackpool claims was the first electric tramway in the country, was opened in 1885. It was owned and run by a private company. In 1892, Parliamentary sanction was obtained by the Corporation to acquire the undertaking and the plant and rolling stock were

bought for £15,750 in 1893. Parliament, however, till the late nineteenth century was reluctant to allow the municipal operation of public utilities. Liverpool, for example, was refused in 1889. Huddersfield broke through this restriction in 1892, and Blackpool 'took the law into its own hands and ran its tramway system for some time without having obtained Parliamentary Sanction.'<sup>2</sup> Since that time to March, 1936, Blackpool transport has made a total net profit of £727,014, £223,497 going to rate relief and £413,874 to other purposes.

Another profitable investment was the purchase of the foreshore rights, 1889 and 1894, for £960. The net yield for rent of stalls in 1934-35 was £4,575, and in 1935-36, £4,466.

In 1893, the generating station at Princess Street was opened by Lord Kelvin. Since that date to March, 1936, the electricity department has made a net profit of £556,466, of which £225,104 has gone to rate relief and £124,111 to other purposes.

The more recent events in the history of the municipality must be mentioned very briefly. In 1900 the Musical Festival was inaugurated and has since achieved such fame as to be an essential part of the autumn attractions, the most important item in which, however, is undoubtedly the Illuminations, which began in 1927. In 1904, Blackpool was constituted a County Borough, and in that year instituted the first motor car speed trials, when the Promenade became a racing track. In 1905, the New Promenade was opened and speed trials were again organised. In 1909, the first Aviation Meeting was held, and in 1912, the Princess Parade was opened by H.R.H. Princess Louise. In the following year Blackpool was honoured by the visit of Their Majesties King George and Queen Mary. The years 1921-23 saw the construction, at a cost of £95,118, of the Open-air Swimming Bath, in which the Olympic Trials of 1924 were held. In 1926 Stanley Park, which to the present has cost £275,070, and the South Shore Promenade Extension, were opened by Lord Derby, on October 2nd. Lastly, another attempt to extend the season, but this time in the earlier part of the year, was successfully made by the introduction of Guest Week, in June, 1933.

#### AMUSEMENTS RUN BY PRIVATE ENTERPRISE.

It is in the chief hotels and public houses that we find the earliest organisation of entertainment. These provided facilities for games and dancing and some of them had 'singing rooms' where professional entertainers were employed. Only one of them now remains, in Uncle Tom's Cabin at North Shore. The Belle Vue Hotel, on Whitegate Drive, for example, in its early days had a famous bowling green, a ballroom which was also used for variety performances, and an outside dancing platform. There were also gardens, an orchard and a croquet lawn. Further afield, Cherry Tree Gardens, in Marton, and Castle Gardens, in Carleton, provided similar attractions and invited daily excursions by horse-brake and carriage.

#### THE PIERS.

In 1861 the leading townsmen held a meeting at the Clifton Hotel to discuss the provision of amusement for visitors. This led to the formation of the

<sup>2</sup> 'A Century of Municipal Progress,' ed. W. A. Robson, p. 321.



Blackpool Pier Company, with a capital of £12,000, and the original North Pier, little more than an oversea promenade, was opened on May 21st, 1863, at a cost of £13,540. A Jetty for pleasure steamer traffic was constructed in 1866, and in 1874 two wings were added. On one was built the Indian Pavilion, since replaced by a larger one after its destruction by fire, and now the home of Lawrence Wright's annual 'On With the Show.' On the other were an open bandstand and shops. The Pier has since been widened and a pavilion and arcade added.

The Central Pier was opened on May 30th, 1868, and soon became known as 'The People's Pier,' because of the popularity of the dancing and roller skating. The White Pavilion was erected in 1907, and ever since has been famous for its pierrot shows.

The Victoria Pier, which was opened on Good Friday, 1893, attracts crowds to its orchestral concerts and its pierrots.

#### THE RAIKES HALL.

The most ambitious and successful venture in entertainment until about 1890 was the Royal Palace Gardens, or the Raikes Hall. The Hall, together with the estate of 40 acres, which included the Number 3 Hotel, was purchased for £14,000 by a syndicate, the Raikes Hall Park, Gardens and Aquarium Company. The grounds were opened in 1872, with the main entrance where the Grammar School now stands, and were laid out with a terrace, promenade and flower-beds, and, in 1875, a lake for boating. A large ballroom, an outside dancing platform, a conservatory encircling a skating-rink, an aviary and monkey-houses were added, and a music hall pavilion introduced to Blackpool many of the stars of the day. Elaborate fireworks at night gave representations of historic battles.

In the early 'nineties, the Raikes Hall declined in popularity after the opening of the Tower. What was left of the estate came under the hammer in 1896, and 14 acres realised £80,000. The remainder, including the Number 3 Hotel, had already been sold. The blame for the loss to the ratepayers of a splendid opportunity is still a matter of some argument since the townspeople vetoed a proposal that the estate should be acquired by the Corporation and retained as an open space.

#### THE THEATRE ROYAL.

The Theatre Royal, built on the site of the present Tivoli and Yates's Wine Lodge, was originally the Arcade and Assembly Rooms. These were opened in 1868, and were described as containing 'a basement and arcade of very elegant shops, a restaurant, together with a handsome and spacious saloon surrounded with a gallery and fitted with a neat stage for theatrical representations.' The Theatre Royal, once the most important in the town, also declined in popularity, and the entire block was offered to the Corporation for £16,000, but refused. This, again, is the subject of occasional argument when the suggested sites for the proposed Town Hall are being discussed.

#### THE WINTER GARDENS AND BIG WHEEL.

The Blackpool Winter Gardens and Pavilion Company was registered on August 7th, 1875, with a capital of £50,000, and purchased for £23,000



Dr. Cocker's Bank Hey residence, 'with the conservatories, aviaries, forcing-houses and about 18,000 square yards of land.' The opening of the Gardens, in 1878, by the Lord Mayor of London, marks the beginning of large scale enterprise in Blackpool. They included a Pavilion, Skating-rink, Floral Hall, Fernery and Gardens. Her Majesty's Opera House was opened on June 10th, 1889, by the D'Oyley Carte Opera Company, in 'The Yeoman of the Guard.' It was rebuilt and opened in 1911, and renovated in 1933, and has a seating capacity of 1,820. In 1896, the Empress Ballroom was built on the site of what had been successively a skating-rink and a circus. In 1897, the Pavilion, with a seating capacity of 2,000, was reconstructed, together with the Indian Lounge. In the last few years considerable improvements have been made at the huge cost of £250,000. In the present year the Gardens were able to house under one roof the 4,000 delegates to the International Rotary Conference. They give employment to more than 600 persons during the season, and in 1935, paid more than £17,000 in entertainment tax.

The Big Wheel was opened on August 22nd, 1896, and in 1916 was purchased by the Winter Gardens Company for £1,150, an additional £2,763 being spent on repairs. This famous landmark was demolished in the winter of 1928-29. The site is now occupied by Olympia, which was opened on June 7th, 1930.

#### THE TOWER COMPANY.

The Blackpool Tower Company was registered on February 19th, 1891, to acquire for £94,000 the full benefit of a contract entered into by the Standard Contract and Debenture Corporation, Ltd., to purchase for £60,000 from the Blackpool Central Promenade Estate Company, Ltd., the original aquarium and other buildings on the site of the present Tower.

In 1874, an aquarium, menagerie and aviary had been opened on what was formerly the site of West Hey, the residence of Sir Benjamin Heywood. They were sold in 1880, together with the Beach Hotel and surrounding property, to the Blackpool Aquarium Company for £46,000, and sold again in 1882, for £50,000, to the Central Promenade Estate Company, and yet once more in 1888, to the Standard Company for £60,000. The Standard Company failed to carry out its contract to purchase, which was taken by the Tower Company, under the late Sir John Bickerstaffe, on condition that the price offered to them was reduced to £72,800.

The foundation of the Tower was laid on September 25th, 1891, by Sir Matthew White-Ridley, and the Tower, Circus and other buildings were opened on Whit Monday, 1894. The ballroom, with a capacity of 6,000, was opened in 1899, and in the following year the Circus was remodelled to hold about 3,000. The height of the Tower to the top of the flag staff is 519 feet 9 inches, to the crow's nest, 480 feet. More than £150,000 have recently been spent on improvements, a huge expenditure justified by the fact that over 40,000 have passed through the turnstiles in one day.

The Palace was originally known as the Alhambra, the foundation stone of which was laid by Mr. George R. Sims, on December 4th, 1897. Opened on May 22nd, 1899, it comprised a Variety Theatre, Circus, Ballroom, Lounges and Refreshment Rooms, which were built on the site of the former Prince

of Wales's Theatre, Baths and Arcade. The Company went into liquidation in 1902, and the entire assets, estimated at £381,052 were purchased by the Tower Company for £140,347. Many alterations have been effected since then and the present buildings contain a Variety Theatre (seating capacity 2,360), a Picture Pavilion (seating capacity 1,950), Lounge and Ballroom.

The Grand Theatre ('Matcham's Masterpiece') was opened on July 23rd, 1894, by Mr. Wilson Barrett, in 'Hamlet.' It was purchased by the Tower Company in 1907, for £47,000. Its seating capacity is 1,660.

On January 18th, 1928, the Tower Company offered the shareholders of the Winter Gardens, in exchange for their holdings, an equal number of fully paid-up ordinary shares of the Tower Company, which now holds the whole of the 105,000 shares of the other Company. In the season the Tower Company employs more than 1,500 persons, a number greater than the total population of Blackpool 100 years ago. In its four main buildings, 50,000 people can be accommodated at any one time.

### THE PLEASURE BEACH.

The Pleasure Beach Estate Company was founded by the late Alderman W. G. Bean, in partnership with Mr. W. Outhwaite. The Pleasure Beach in 1901 has been described as an unpretentious fairground, but since the War it has seen much alteration and enlargement. Its present Managing Director, Mr. Leonard Thompson, annually visits America and the Continent in quest of the new attractions which every year draw millions of visitors to South Shore. The strikingly effective designs of Mr. Joseph Emberton are the most pleasing examples of modern architecture to be found on this coast.

### CINEMAS.

The first cinematograph show in Blackpool was in March, 1907. Very soon existing buildings were adapted, and in 1909 the first specially-constructed Cinema was opened, the Royal Pavilion in Rigby Road, now the Plaza. Blackpool now has 15 Cinemas with seating accommodation for more than 20,000.

### BLACKPOOL TO-DAY.

This brief survey of the history of Blackpool may help to explain the present position of the town as third, after Liverpool and Manchester, in Lancashire, in rateable value, and third in rateable value also, after Brighton and Bournemouth, of the English seaside resorts. Its popularity shows no signs of diminishing in its power to attract both visitors and permanent residents. Its population is still growing. The number of visitors now annually exceeds 6,000,000, and nearly 6,000 establishments cater for their lodging. The greatest increase in this respect is due to the long-distance visitor. While the last Autumn Illuminations attracted 733,000 passengers by rail and at least an equal number by road, it is of even greater importance that the number of period tickets sold on the railway in the last season was more than double the number in 1924.



## ADVERTISING.

Much of this expansion is undoubtedly due to the energy of the Publicity Department in devising successful schemes of advertising. More than 80 tons of holiday literature were circulated in the last season. In addition to the large Summer Guide, special programmes were printed for the Autumn Season, the Early Season and the Christmas Season, making more than a million copies in all. All the large industrial areas have special agents and part of their work consists of organising in workshops, clubs and Sunday Schools, saving societies for a Blackpool holiday. More than 200 such saving societies are already in existence. The Department uses every medium of public persuasion—the press, the poster, the printed lecture illustrated by lantern slide and film, and, of course, the cinema, through the making of successful movies by the Gaumont British Company. Lastly, the success of Blackpool as a ‘Congress City’ is a potent means of broadcasting the fame of its amenities.

## ECONOMIC PROBLEMS.

The rapid expansion of the Borough has created problems of growing complexity which have been successfully solved by the administrative efficiency of the Corporation. Yet there have arisen also economic difficulties which are not so easy to solve. Most urgent is the problem of seasonal unemployment. Part of the rapid growth of population in the last few years is undoubtedly due to the influx, from the depressed areas, of seasonal workers who, at the end of the season, decide it is useless to return to industry and remain unemployed until the next summer, as permanent residents. The fluctuation in employment is greater here than in the south coast resorts which have more visitors in the winter. This gives a greater urgency to what is perhaps the question of first importance to the business man—how to extend the season.

## CONCLUSION.

Blackpool has chosen as its motto the word ‘Progress.’ To the millions of visitors it signifies a promise of initiative and enterprise in catering for an ever-changing public taste. To the Borough Council it means the administrative efficiency which has enabled private enterprise to create for Blackpool a world-wide fame as the ‘City of Health and Pleasure.’

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My thanks are due to Mr. Ben Bowman, the well-known local historian, and to Mr. A. F. Warner, Chief Reporter of ‘The West Lancashire Evening Gazette,’ for their generous help.



## XV.

## MUNICIPAL LIFE OF BLACKPOOL

BY

D. L. HARBOTTLE, LL.B., TOWN CLERK.

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BLACKPOOL was in its origin a small hamlet on the Lancashire coast inhabited mainly by fishermen. The earliest record of 'de Poole,' or 'de Blackpoole,' is contained in the Parish Church registers of the neighbouring villages of Bispham and Poulton-le-Fylde between 1592 and 1602. In the reign of King Charles II., one Edward Tyldesley (son of Sir Thomas Tyldesley, killed in the battle at Wigan Lane, 1651) erected a hunting lodge here known as Fox Hall, near the sea shore, and not far from the present Foxhall Hotel. His name is also remembered by an important terrace of houses known as Tyldesley Terrace, a road named Tyldesley Road, and by Tyldesley Ward—a part of the borough for electoral purposes.

This summer residence of the Tyldesleys was a small three-gabled building with a look-out tower, and over its main entrance was the Latin motto : '*Seris Factura nepotibus*' ('As thou sowest so shall thy children reap'), the headstone of the south gateway bearing a sculptured pelican feeding her young. It was built somewhere between 1655 and 1665, and towards the end of the seventeenth century the hunting lodge was extended into a large country seat. Gradually a village grew up around the country mansion, and in time visitors were attracted to the locality by the recuperative properties of the sea breezes, the expansive sands and the excellent bathing facilities.

Blackpool obtained its name, as many other towns and hamlets, from its natural surroundings. Its ancient site was on the banks of an old pool, the waters of which were of a dark black colour and peaty nature. About the year 1851, the small village of Blackpool (then known as Layton-with-Warbreck) had grown to an appreciable extent. The population, according to the census of 1851, was 2,564.

On the 23rd October, 1851, Layton-with-Warbreck was constituted a Local Government District by order of the Local Government Board, and a Local Board of Health was elected. The popular name of the township for many years had been 'Blackpool,' and in 1868 the name of the Local Board was altered, and the Board continued under the title of the Blackpool Local Board of Health. It became the Burial Board under the Burial Act, 1857, by virtue of an Order in Council dated 16th May, 1871. On the 21st January, 1876, a Charter of Incorporation was granted by Her late Majesty Queen Victoria. At that date the population was approximately 10,000, and the rateable value £76,838. To-day, in the Diamond Jubilee of its history as a municipal borough, the resident population approximates 125,000, and the rateable value is £1,530,769. These figures indicate to some extent the striking development of the town during the past 60 years.

The boundaries of the borough have been extended on four occasions, namely : in 1879, by the addition of part of the township of Marton at the south-east end and part of the township of Bispham-with-Norbreck on the north ; in 1918, by the inclusion of the urban district of Bispham-with-Norbreck and part of the township of Carleton on the north and north-east respectively ; in 1920, by the addition of a large strip of the foreshore, co-extensive with the western boundary of the borough, extending below low-water mark ; and lastly, in 1934, the borough was further extended to include other parts of the townships of Marton and Carleton and a part of the township of Hardhorn-with-Newton. The area is now 10,580 acres (including foreshore). The number of the Council at date of incorporation was 24. To-day it is 56. The borough has a separate police force and Commission of the Peace.

Blackpool was raised to the status of a county borough on the 1st October, 1904. For Parliamentary representation Blackpool forms with the adjoining borough of Lytham St. Annes the Blackpool Parliamentary Borough. The electorate is over 100,000 and a redistribution of seats is evidently much overdue. In spite of such an abnormal electorate it is only a single-member constituency.

Some indication of the growing activities of the municipality may be gathered from the number of Acts of Parliament and Provisional and other Orders obtained since 1853—17 Acts and 33 Orders.

In several important matters Blackpool, in obtaining Parliamentary powers for the good government of the borough, has been in advance of Parliament's general legislation. One outstanding instance in this respect is the power obtained by the Blackpool Improvement Act of 1879 to expend an amount not exceeding twopence in the £ on the borough's rateable value in advertising the attractions and amenities of the town. The amount expended under this heading by the Council last year was £15,854.

Blackpool's principal asset is unquestionably its fine Promenade.

As the erosion of the coast was becoming serious, Parliamentary powers were sought in the early Sixties to protect the sea front. The first Bill promoted in Parliament by the then Local Board was unsuccessful on financial grounds, as it was proposed to levy a rate equally over the district, whereas the Lords Committee in Parliament decided that the cost should be borne only by those having property on the front who would be directly benefited by the improvement. In 1865 a Local Act was obtained in which was a clause providing that a special parade rate should be levied on all frontagers, and the period for payment of this special rate has still 13 years to run. Under the powers of the 1865 Act and a supplementary Act (1868) increasing the borrowing powers of the Board, the sea defence works and promenade extending from Carlton Terrace (just north of the Hotel Metropole) to the South Shore end (near Victoria Pier), a distance of about two miles along the sea front, were completed and opened on Easter Monday, April 18th, 1870.

In 1876 that part of the sea front extending northwards from Carlton Terrace to the Gynn, a distance of about 1,267 lineal yards, the property of the Claremont Estate Company, was sloped and stone pitched, and a broad marine parade and drive made, all at the cost of the Company. The erosion on this part was, however, so constant and serious that in 1893 the Corporation



promoted and obtained an Act of Parliament authorising the construction of new sea defence works and promenade known as the 'North Shore Works.' These works, constructed in three tiers, were popularly known as 'the three-decker,' and comprised a carriage drive, middle walk, and lower parade. They were completed and opened in 1899.

The Blackpool Borough Engineer and Surveyor (Mr. H. Banks) who from his early years has been intimately associated with the Borough's sea defence works, gives elsewhere full particulars of what has been accomplished since 1895. The Corporation are the owners of the foreshore from end to end of the borough, having acquired it at various dates from the Duchy of Lancaster, and, by purchase, the Lords of the Manor of Layton, which comprises a large part of the borough.

### THE CORPORATION'S UNDERTAKINGS.

Few towns are, unfortunately, in the happy position of Blackpool as regards municipally-owned and operated undertakings. The Corporation own and work the following: Gas, Electricity, Markets, Tramways and Buses, Sea Water Works, Public Baths, Parks, Airport, Cemetery, Public Abattoirs, Public Libraries and Housing Schemes.

#### GAS.

With few exceptions the undertakings are commercially prosperous, and contribute substantial sums to the relief of the rates. The oldest is that concerning the manufacture and supply of gas and residuals. Gas was first supplied in Blackpool in 1851 by private enterprise. The works were not a success, and in 1862 they were taken over by the then Local Board, and leased for seven years. In 1869 the Local Board resumed possession, and the Corporation as their successors have administered the undertaking. Sixty years ago there were 2,000 consumers; to-day the figure is 38,000. In 1896 there were 53 miles of mains, and in 1936 over 250 miles. During the 12 years preceding the town's incorporation (1876) the price of gas ranged from 5s. 10d. down to 5s. per 1,000 cubic feet. To-day the price varies from 2s. 3d. to 2s. 9½d. per 1,000 cubic feet. Over 5,000 gas lamps are required to light the borough.

The capital expenditure of the undertaking up to March, 1935, was £610,339.

#### TRAMWAYS AND BUSES.

The formal opening of Blackpool's tramway undertaking took place in October, 1885, and the most sanguine anticipations of the operators, the Blackpool Electric Tramway Co., Ltd., were realised. The Company possessed only 10 cars, each with a carrying capacity of 34 to 52 passengers, and it was thought they would be sufficient to meet requirements for all time.

The lease to the operating company expired in 1892, and the Corporation then took over the undertaking. The electric conductors were originally placed under the road surface, on what was known as the conduit system, operated at 250 volts pressure, there being no system of overhead traction in



operation in this country at the time. The close proximity of the tram track to the sea resulted in many stoppages, and with stiff westerly breezes both sand and water blew over to such an extent that the traffic had to be suspended for as much as two or three consecutive days, during which period it was necessary to caulk with ropes the slots in the tram track so as to minimise the filling up of the channels. After much controversy and a visit by a Council deputation to Continental cities, the overhead traction system was installed (1898), and to-day Blackpool has an exceedingly fine fleet of tramcars, older stock being gradually replaced by cars of the latest design. From the small beginning in 1885 with 10 cars, the undertaking has had a remarkable development. In 1919 the Corporation obtained an Act of Parliament confirming their purchase of the Blackpool and Fleetwood Tramroad Company's undertaking, and became owners and operators of the tramways from Blackpool northwards to the borough of Fleetwood.

In 1924 the re-laying of the track from Cocker Street (north) to the Gynn led to removing the tramway from the carriage drive. This was effected by converting the westerly footpath of the Promenade and part of the slope leading down to the Middle Walk into a separate tram track laid on a sleeper foundation (thus ensuring smooth running of the cars), and leaving the carriage drive free for vehicular traffic. A new footpath on the westerly side of the new tram track was formed by the erection of an overhanging cantilever, providing thereunder on the Middle Walk a sheltered walk throughout, with continuous seating. Colonnaded embayments were also constructed on the Middle Walk. The works were completed in February, 1925, at a cost of £42,000.

The Corporation, under their statutory powers, and subject to the Road Traffic Acts, have also established excellent bus services in the borough, and mutual running powers to a certain extent exist both as regards tramcars and buses between Lytham St. Annes, the adjoining borough on the south, thus providing a well-equipped service of transport from Fleetwood on the north to Lytham St. Annes on the south. From the yearly profits of the transport undertaking handsome sums are contributed to the relief of Blackpool's rates. In 1896 the number of passengers carried was 1,440,570. Last year there were 49,092,454 passengers on the tramcars and 14,318,995 on the buses, a total of over 63 millions.

There are 196 tramcars and 82 Corporation-owned buses, and another 25 are on order. The Corporation now possess power to operate electric trolley buses.

### ELECTRICITY.

The Corporation were pioneers in the use of electricity for lighting and traction purposes.

Powers were obtained in the Tramways Orders Confirmation Act, 1884, to run tramways along the Promenade on the conduit system by electricity. An Electric Lighting Order was obtained in 1890, and by July, 1892, a move was made in the erection of works. On 13th October, 1893, the works were opened for supply by Lord Kelvin, one of the foremost scientists of his day. Here again is an instance of the development of an undertaking being phenomenal. The Corporation began business with 30 consumers, their

demand being for supply to 3,000 eight-candle-power lamps. During the last five years the number of consumers has grown from 20,960 to 33,264, and the sale of current from 38,326,532 to 47,068,115 units. With the exception (in its earlier days) of some five or six years, the undertaking has been commercially successful, contributing from its profits substantial sums to rate relief.

The area of supply includes districts adjoining Blackpool which are supplied under powers contained in Fringe Orders. The greater part of the current is now obtained in bulk from the Preston Corporation under orders of the Central Electricity Board. The electricity mains total 676 miles, and the electric lamps for public lighting number 2,942.

### EDUCATION AND PUBLIC LIBRARIES.

Close upon 20 Council schools have been erected since the first Board school was opened in 1902. As the result of recent Parliamentary and Departmental activity, the Corporation, as the Local Education Authority, are faced with the difficult and expensive problem of providing further school accommodation. At the two secondary schools, the Boys' Grammar School and the Girls' Collegiate School, there are over 800 children in average attendance. A fine Technical College is also nearing completion.

The Free Library Acts (as they were then termed) were adopted as far back as 1879, and the Public Library was established in the Octagon Room of the Assembly Rooms (now Yates's Wine Lodge) in Talbot Square in 1880. This Library was officially opened on the 18th June of that year by the then Right Hon. the Earl of Derby. In March, 1895, the Library was removed to more commodious premises in the new Municipal Buildings, which had meanwhile been erected in close proximity to the present Town Hall. In the progression of time branch municipal libraries have been opened in several parts of the borough. Mr. Andrew Carnegie, on the 10th April, 1906, intimated that he would be glad to provide £15,000 for a Free Public Library. The building was erected at the corner of Maybell Avenue and Queen Street.

An Art Gallery, the gift of Sir Cuthbert Grundy, J.P., and his brother, Mr. J. R. G. Grundy, was erected on the Queen Street side, adjoining the Library. Both buildings were officially opened on the 26th October, 1911. The Carnegie Library was opened by the Mayor (Councillor W. H. Broadhead, J.P.), and the Art Gallery by the Right Hon. the Lord Shuttleworth, Lord Lieutenant of the County of Lancaster.

### PUBLIC PARK.

An extensive Public Park on the easterly side of the town was designed and the laying-out supervised by Messrs. Thomas H. Mawson and Son, of Lancaster. It was formally opened on the 2nd October, 1926, by the Right Hon. the Earl of Derby, K.G., and bears the name of Stanley Park. Parts of the park area were generously presented to the Corporation by the late Alderman Sir John Bickerstaffe, J.P., Thomas Marquis Watson, Esq., and William Lawson, Esq.



A Municipal Golf Course adjoins, as also does the Blackpool Cricket Ground (the latter the gift of the late Sir Lindsay Parkinson, J.P., and his brother, William Parkinson, Esq., J.P.).

There is a boating lake of some 26½ acres in extent. Bowling, putting, tennis, cricket, and football are amply provided for. There are also children's playgrounds, and a spacious open-air band stand and auditorium. The execution of the work has been spread over a period of five years, and on completion its cost will approach, if not exceed, £250,000.

#### OPEN-AIR SWIMMING POOL.

On June 9th, 1923, the Mayor of the borough, Councillor Henry Brooks, J.P., officially opened the South Shore Open-air Swimming Bath. Erected at a cost of approximately £80,000 by the Corporation, the bath is one of the largest and best-designed open-air swimming pools in the world. It covers an area of four acres, and provides accommodation for 3,000 bathers at one time, and 8,000 spectators on the half-mile of terraces.

There are 868 dressing rooms, 500 lockers and 1,300 special clothes containers. The latter are used in conjunction with the 268 gas-heated cubicles, completed this season, and the rooms are equipped with foot-baths, showers, etc.

Another additional novel feature is the large sun-bathing terrace projecting into the water, erected in 1935.

The area of the pool is 60,000 square feet, the extreme length 376 feet, and the width 172 feet. The depth of the water varies from 1 foot 6 inches to 4 feet 6 inches, except in the championship area, which is exactly 110 yards long by 25 yards wide, and varies in depth from 4 feet 6 inches to 5 feet 6 inches. The diving pool shelves to a depth of 15 feet, and the diving stage consists of seven platforms, varying in height from 4 feet to 32 feet 6 inches (10 metres). A triple water chute and shower baths are provided, and a portion is reserved for instruction in swimming.

The bath contains 1,600,000 gallons of filtered sea-water, which is being constantly changed, purified and aerated at the rate of 80,000 gallons per hour by powerful and electrically-driven pumps. The water is first pumped from the sea into a huge settling tank capable of holding half-a-million gallons, then transferred to the four filters, and finally pumped into the pool in a novel and artistic fashion through 20 fountain-like sprays and a cascade.

#### BURIALS AND CREMATIONS.

By 1873 land had been acquired by the Burial Board in the Layton district (east) adjoining New Road, now named Talbot Road. The Cemetery grounds—some 8 acres in extent—and the consecration ceremony took place on the 3rd August, 1873. There have been several extensions of the Cemetery until all available land there has been acquired. Further accommodation became an acute question a short time ago and land was purchased at Carleton, also on the easterly side of the borough, and a Cemetery formed. A Crematorium has also been erected at this latter cemetery, and is now available for use.



## AVIATION AND AIR PORT.

The late Lord Northcliffe in the autumn of 1909 suggested an aviation meeting at Blackpool. A deputation made two visits to Rheims, and the outcome was the organising of a Flying Week at Blackpool. Many of the leading Continental aviators, such as Messrs. Farman, Paulhan, Latham, Le Blanc, Rougier, and our own countryman, A. V. Roe, accepted Blackpool's invitation and gave daring and exciting exhibitions. The Corporation's interest in aviation has never flagged. Other Air Pageants have been held, at one of which a display was given by members of the Royal Air Force.

An airport, with clubhouse, has been constructed east of the Stanley Park. Here is an instance of Blackpool rendering a national service, the Council having expended no less a sum than £81,957 up to the 31st March last year on this undertaking, and in the purchase of a large area of land adjoining.

## HOUSING.

The Corporation, on 10 housing estates and with houses acquired, have provided nearly 1,400 dwellings.

The capital expenditure amounts to £1,177,310. Subsidies to the extent of £125,845 have been granted to 1,704 persons in respect of houses erected by them, and £245,867 has been advanced on mortgage under the Small Dwellings Acquisition Acts in respect of 387 properties. The Corporation housing rentals vary from 6s. 8d. to 13s. 6d. per week.

## PUBLIC HEALTH SERVICES.

The Medical Officer of Health, who is also the Chief School Medical Officer for the county borough, directs the varied activities of the Health Department. In addition to the general sanitation of the area, he is responsible for the hygienic condition of all factories and workshops, bake-houses and all milk and food preparation and storage premises. In a prominent health resort like Blackpool these duties are of the greatest importance in ensuring the provision to the general community of a pure and wholesome food supply.

The Maternity and Child Welfare Scheme embraces the care of the expectant mother during the whole of her pregnancy, the provision of special ante-natal clinics in the northern, central and southern areas of the town, and the provision of a Maternity Ward. The working is in the hands of a special medical officer under the direction of the Chief Medical Officer of Health, and in addition to the ante-natal treatment, there are held in each area of the town Infant Welfare Centres where the children from birth to the age of five years are cared for, in order that on attaining school age they may be handed over to the School Authority well in health and fitted to commence their scholastic duties.

Periods of rest and quiet are provided at convalescent homes for the weakly mother, and great benefit results. Financial assistance is rendered to the midwifery profession when dealing with cases of distress or financial difficulties. Dental treatment is also provided for the expectant and nursing mothers and young children, and this has resulted in great benefit to the recipients.

In the diagnosis and treatment of Tuberculosis the actual working of the Blackpool scheme is carried out by a specialist tuberculosis officer under the direction of the Medical Officer of Health. The scheme embraces visiting of patients and contacts, dispensary treatment, residential institutional treatment for both early and advanced cases, and the provision of additional nourishment where the patient is not requiring institutional treatment.

In the care of cases of infectious disease much benefit has resulted in the appointment of a special nurse, by her advice as to the precautionary measures to be taken, and the segregation of the contacts. The Isolation Hospital of 82 beds is also under the superintendence of the Chief Medical Officer of Health.

The Public Abattoirs are also governed by the Health Department. The general supervision and inspection of all meat prepared for consumption at these premises is in the hands of a specially qualified meat inspector, so as to ensure that no diseased meat finds its way into the hands of the public.

All offensive trades in existence in the borough, except fish frying, are confined to and carry on business at the public abattoir, and are under the constant supervision of the Medical Officer of Health.

#### PUBLIC CLEANSING.

Great vigilance is exercised in the cleansing of the streets of the borough, and in the disposal of house and trade refuse. The department is well equipped with up-to-date motor vehicles. The disposal of all refuse is by way of incineration at recently-erected works, where the latest machinery is in operation.

This department is also responsible for the daily removal of any refuse from the foreshore.

#### TOWN PLANNING AND BUILDING DEVELOPMENT.

The whole of the borough is affected by three schemes. The first resolution to prepare for Scheme 1 was in 1922, and from that year the Council acted under the powers they obtained in an interim development Order up to the time of approval of the scheme.

No. 1 scheme embraces the unbuilt-up area ; No. 2 the area recently added to the borough ; and No. 3 scheme the built-up area of the town.

No. 1 scheme, which was the first to be prepared, has been in operation since February, 1933, in reservations for a number of very important road proposals, areas for residential purposes, shopping, business and industrial buildings.

Restrictions are also included with respect to the use of land and buildings, the control of advertisements, space about buildings, height and density of buildings, and other powers to control amenity and general development.

Scheme No. 2 is in course of preparation, and will within the next few months be submitted to the Minister of Health for approval. The proposals contained therein are similar to those in Scheme No. 1.

Scheme No. 3 is of particular interest, as it deals with the built-up area of Blackpool, and is one of the first of its kind in the country to be submitted.



It has received the approval of the Minister of Health, and is now awaiting submission to the House of Commons and the House of Lords for final approval. The provisions generally are for the preservation of existing residential areas, which is a necessity for a seaside town like Blackpool. It also gives the Corporation power to control the maintenance, use, alteration, extension and replacement of existing buildings, and the continuance of existing use of land and buildings and the provision of loading accommodation to business premises.

Building development by private enterprise has been phenomenal in Blackpool during the last few years. An average of 1,250 dwelling-houses have been built each year for the past 10 years, and apart from this, a large amount of money has been spent on the re-building and the erection of new shops, stores, public buildings, hotels, licensed premises and boarding houses. The Corporation have powers to control the elevations of new buildings.

### ARTERIAL ROADS.

Since 1920 a large number of widening and reconstruction schemes of the existing main roads within the borough has taken place, while a number of new roads giving better inter-communication have also been constructed. The principal road arteries leading into Blackpool are as follows :—from the south, Clifton Drive, Squires Gate Lane and the Promenade ; from the south-east, Preston New Road ; from the east, Newton Drive ; and from the north-east, Poulton New Road ; from the north, Queen's Drive and Fleetwood Road. Undoubtedly the main artery into Blackpool is Preston New Road, which discharges into the junction of Whitegate Drive and Waterloo Road and Park Road, at which junction a traffic round-about is situated. From here the traffic bound southwards is borne along Waterloo Road, while that for the centre of Blackpool can travel by Park Road, and that proceeding to the north end of the borough along Whitegate Drive and thence by way of Devonshire Road to Cleveleys.

The reconstruction and widening of Preston New Road to 100 feet was for a distance of 1.4 miles undertaken in conjunction with the Lancashire County Council, while the construction of Poulton New Road 60 feet wide was also undertaken with their co-operation. The total length of Class I. roads scheduled by the Ministry of Transport within the borough, widened and constructed during the period from 1920 onwards, is 19.70 miles, while the length of secondary roads, or those scheduled as Class II. by the Ministry of Transport, is 9.41 miles. The total mileage of unclassified roads is 151.14 miles, making a grand total of 180.25 miles under the jurisdiction of the Corporation. The remodelling of these arterial roads involved the construction of four railway bridges, viz. : at Squires Gate Bridge Lane, Harrowside, Bispham Bridge, Devonshire Road Bridge. A large proportion of the expenditure involved in the construction of these roads was borne by the Government and the total nett cost to the Corporation was an expenditure of £697,675. The majority of the roads thus constructed have been surfaced with either bituminous or mastic asphalt, and have stood up remarkably well, and maintenance costs have been low, while the foundations have been constructed in 6 to 1 Portland cement, concrete or rubble.



A boulevard, 60 feet wide, called Park Drive, encircling Stanley Park, has also been constructed, and as this has direct access to Preston New Road by means of South Park Drive, traffic wishing to proceed to the northerly end of the borough can by-pass the town by proceeding along West Park Drive, Collingwood Avenue, Plymouth Road, Bispham Road, thence along Devonshire Road to Cleveleys.

In concluding, I desire to express my appreciation of the valuable assistance rendered by Mr. Arthur S. Wright, formerly Chief Clerk in my department, and members of the Corporation staffs concerned.

## XVI.

# BLACKPOOL COAST DEFENCE WORKS

BY

H. BANKS, M.INST.M. & C.E.

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DURING the past 40 years the Blackpool Corporation has expended over £1,156,000 on the various sections of sea-defence works and promenades. The author will give a brief account of the sea-coast defence works carried out at Blackpool during the above period.

The County Borough of Blackpool is situated at the westward or seaward extremity of that part of West Lancashire known as the Fylde. The total length of the foreshore or sea-front is seven miles, and runs almost due North and South, now all protected by sea-defence works.

The range of an ordinary spring tide is approximately 27 feet. The flow of the tide is from South to North, and the ebb from North to South-West. The flood tide is stronger than the ebb.

## WORKS FROM 1895 TO 1936.

Fig. No. 1 is a key plan showing the whole sea-front of Blackpool.

The writer's first experience of sea-defence works dates back to 1895, when the Corporation promoted and obtained an Act of Parliament to construct the North Shore works, extending from Carlton Terrace to the Gynn, a length of 1,267 yards.

The erosion on this part of the sea-front had been constant and serious, valuable property being jeopardised by the inroads of the sea.

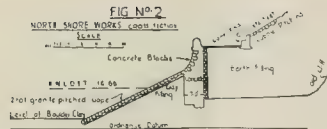
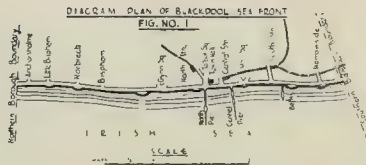
The scheme, which was designed by the late Mr. J. Wolstenholme, A.M.I.C.E., then Borough Surveyor, was carried out by contract. Work was commenced in 1895, and the scheme completed in 1899 at a cost of £150,000.



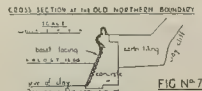
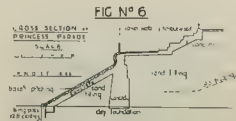
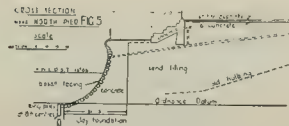
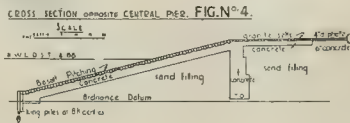
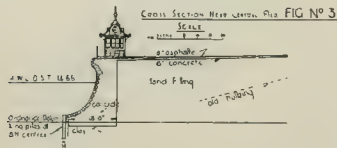
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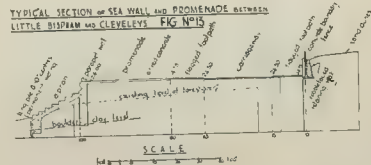
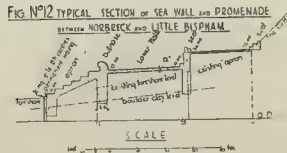
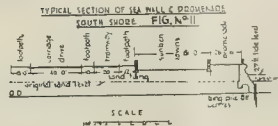
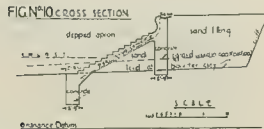
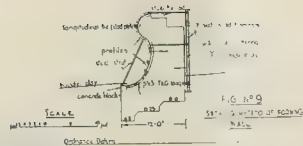
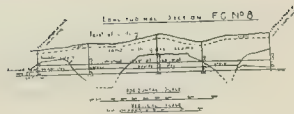


Fig. 2 is a cross section of these works, the main feature being a concrete sea-wall and parapet, with a 2 to 1 apron formed of 15-inch granite cubes pitched on a bed of 6 inches of P.C. concrete, overlaying a filling of puddled clay.

It was about the same time found that the promenade (from the south end of the newly-constructed North Shore works to South Shore) was rapidly becoming inadequate to cope with the ever-increasing annual influx of visitors, so in 1899 a scheme for widening that part of the promenade seawards for a uniform width of 60 feet was sanctioned by Parliament, at an estimated cost of £350,000. At this time Mr. J. S. Brodie, M.I.C.E., was appointed engineer to the Corporation, and he strongly advised the Local Authority to increase the widening from 60 to 100 feet.

The requisite authority for the extra widening having been obtained from Parliament by the Blackpool Order (No. 1), 1902, the work was proceeded with at the South Shore end in the early spring of 1902 by direct labour under the supervision of the author, who was appointed Chief Resident Engineer. The author would here like to state that the sea walls, Figs. 3 to 8, were designed by his chief, the late Mr. J. S. Brodie, after inspecting all the principal sea-walls in the United Kingdom and on the Continent.

The main length of wall, commenced in the spring of 1902, was completed and opened as far as the North Pier in July, 1905, a distance of 3,184 lineal yards.

A sea-wall 380 lineal yards in length from the north end of the North Shore works to what was at that time the northern boundary of the borough, was commenced in August, 1910, and completed in January, 1911.

The sea-wall from the North Pier to Cocker Street (the southerly end of the North Shore works), a length of 400 yards, and called the 'Princess Parade,' was commenced in October, 1910, and completed in September, 1911, and was formally opened by H.R.H. Princess Louise, Duchess of Argyll, on 2nd May, 1912.

Fig. No. 3 shows the general section of sea-wall, a length of 2,384 lineal yards, from the Victoria Pier to the Central Pier.

Fig. No. 4 shows the general section of the southern half, between the Central Pier and the North Pier, a total length of 800 lineal yards, and Fig. No. 5 shows the general section of the northern half of this length. Fig. No. 6 shows the general section between the North Pier and Cocker Street (Princess Parade), a length of 400 lineal yards.

Fig. No. 7 shows the section of the 380 yards length of sea-wall north of the North Shore works.

It will be noticed that no piling is shown at the toe of this wall, the reason being that the boulder clay was too hard to admit of pile driving.

With the exception of 1,700 yards at the southerly end of the works, where a clay foundation could not be found at a reasonable depth, the walls and aprons were taken down to the red clay, and whole timber king piles driven 20 feet below toe level, and spaced at 8 and 12 feet centres: permanent whole timber walings are bolted to the king piles, and Karri-wood close sheeting (varying in length according to the nature of the ground) is spiked to the waling. The



king piles and walings are pitch pine. The walls and aprons are all faced with basalt columnar stone, bedded and grouted in ground Portland cement mortar.

With the exception of a small area of basalt pitching used on the Princess Parade length, and imported from the Giant's Causeway, all the basalt stone was imported from the Rhine and delivered here at the remarkably low figure of 16s. per ton.

The following figures give an idea of the magnitude of the works carried out by the Corporation direct, and not by contract.

213,000 cubic yards of P.C. concrete.

750,000 cubic yards of sand filling.

25,000 tons of basalt stone.

192,000 square yards of asphalt and flagging.

It will be seen from the cross sections, which show the level of the foreshore at the time of construction, and the level at the present time, that accretion is taking place at the southern end of the borough, and erosion is taking place at the northern end of the borough.

Accretion is slowly but surely extending northwards, and is due, in the author's opinion, to the dredging operations taking place in the Mersey and the Ribble, particularly the Ribble, where great alterations in the estuary have been carried out during the last 35 years. The dredgings (chiefly sand) are carried in suspension during the flood tide, and deposited on the foreshore at Blackpool. From the Victoria Pier to opposite Central Beach, a distance of 2,800 yards, the accretion averages 5 feet, and extends to low-water mark of neap tides : from this point to opposite Princess Parade, a distance of 700 yards, the accretion averages 2 feet, and even further north, for a distance of some 700 yards, the accretion averages about 6 inches.

All this accumulation of clean, golden sand, has taken place since the commencement of the works in the spring of 1902. The author wishes to point out that 750,000 cubic yards of filling required in the construction of the work was got chiefly from the foreshore at the southern or Victoria Pier end of the works.

#### SEA WALL FROM OLD BOROUGH BOUNDARY TO ARUNDEL AVENUE.

One of the most bracing and enjoyable seaside walks at Blackpool is over the cliffs to Norbreck and Cleveleys in a northerly direction. These cliffs rise to a height of 100 feet above Ordnance Datum.

The geological formation is, generally speaking, the lower boulder clay, attaining in some places an elevation of 50 feet above Ordnance Datum, and in two cases dipping down at a steep incline to 40 feet below O.D. (see longitudinal section, Fig. No. 8). Overlaying the boulder is a bed of sharp sand, containing deep veins of gravel, and averaging 40 feet in depth, which, again, is covered with the upper boulder clay, about 10 feet in depth.

Prior to the commencement of these works in 1917, the erosion of these cliffs had been at the rate of 2 yards per year during the preceding 30 years. Chiefly in order to preserve them from further erosion (the cliffs have always been considered as greatly adding to the amenities of the county borough),

the Corporation favourably considered a scheme of amalgamation with the Urban District of Bispham with Norbreck, and, in 1917, promoted and obtained a Bill in Parliament to extend the borough in a northerly direction, with powers to construct a sea-wall to protect that length of cliff suffering so severely from erosion by the sea.

Owing to the prohibitive cost of stone suitable for work of this description, coupled with the difficulty of getting delivery of same, it was decided, when the work was started, in August, 1917, to build a self-faced wall, built in *situ*, using a facing mixture of 4 to 1 P.C. concrete, 9 inches thick, with a backing of 8 to 1 P.C. concrete, with a reasonable number of displacers for the bulk of the wall. The almost uniform level of the boulder clay along the line of the wall is 11.50 above Ordnance Datum, and has an inclination seawards of 1 in 20, with an average covering of 12 inches of gravel, where it meets the sandy foreshore at a mean level of 4 feet above O.D. : the foreshore then falls seaward at an almost uniform gradient of 1 in 100 to low water. The excavation for the wall in boulder clay was taken down 7 feet below the surface level of the boulder, at the front of the wall, and then benched up. On account of the rock-like toughness of the boulder clay, gelignite was used to facilitate and cheapen the cost of getting out the trench : small charges were put in some 3 feet away from the seaward side of the trench, so as not to break up the ground on the west side of the wall, and somewhat heavier charges were used for the centre and back.

In the running sand foundation permanent king piles were driven at 12 feet centres and 18 feet below toe level : on account of the high cost and difficulty in obtaining balk timber suitable for the purpose, the author suggested using old tramway rails, 7 inch section, and weighing 98 lbs. and upwards per yard. Holes were drilled in the piles before driving, through which the permanent walings were bolted, and close sheeting piles, 10 feet long, were spiked to the walings.

There was an ample supply of splendid gravel and grit suitable for concrete lying close to the line of the wall. Screening was unnecessary with the exception of the facing material, when all stones over  $\frac{3}{4}$  inch were eliminated. The concrete was mixed on light portable stages fixed over or alongside the trench, and easily removed at high water.

Fig. No. 9 shows the method the author designed to form the wall.

Four-inch diameter cast-iron pipes were built through the wall 40 yards apart to act as ream water outlets : a substantial dry lining backing was built on the landward side of the wall at each outlet.

Nine-inch diameter cast-iron pipes spaced 60 yards apart were also laid through the wall well above high water level to provide for the surface water draining of any future lay-out.

Fig. No. 10 shows a section of the last 270 yards of the work, a reinforced P.C. concrete stepped apron having an 8 inch rise and a 15 inch tread, with a bull-nosed top, a light wall 3 feet in width built to form a "seal" on the landward side of the apron, and to carry the bull-nosed top, being the main features. A similar section was adopted in forming the apron to the first slade for vehicular traffic, and was completed in June of 1919. The work is standing



well, and the back wash from a section of this description is reduced to a minimum.

Two slades were provided for in the scheme, each 100 yards in length, 7 yards in width, with an inclination of 1 in 14 : also eight flights of P.C. concrete steps, leading from the top of the wall to the foreshore, each 12 feet in width.

A good many groynes were erected from the old borough boundary to the northerly boundary of the borough, for a distance of 4,900 yards. Four of the first to be built were constructed in pre-cast concrete blocks, stepped in section on both sides so as to minimise obstruction to pedestrians using the foreshore.

In plan they are part of an ellipse, with the sharp part of the curve commencing at a tangent from the wall and leading away in a south-westerly direction. The height of these groynes abutting the sea-wall is 16 feet above O.D., and they continue at this level for a length of 48 feet, when they are ramped down 1 foot in every 12 for a length of 180 feet. This type of groyne has been very successful on this section of the foreshore.

All the remaining groynes were built of timber, laced horizontally between steel tram rails as piles driven at 6 feet centres, the timbers being laid in slots formed in the rails and secured by iron clamps at the top. This method of construction is cheap, and has served its purpose admirably, many of the groynes having had to be lifted to prevent gravel travelling in a northerly direction.

The groynes are generally spaced 200 yards apart, and are approximately 80 to 100 yards in length.

This section of the sea-coast protection works, a length of 1,980 yards, was completed in 1921 at a cost of approximately £80,000, including the seaward wall built opposite Uncle Tom's Cabin to enclose the proposed open-air bath site at the then northerly end of the borough. This site at the present time is let as a boating pool.

Attrition, due to gravel and boulders driven during the heavy seas against the self-faced wall, is, generally speaking, not so bad. As far as possible, the shuttering on the seaward side of the wall was struck, having due regard to the weather conditions and the height of the tides, during low tides and favourable weather. The lower profiles and shutters were struck after four or five days : the top profiles stood eight to 10 days before striking, and during high tides, coupled with unfavourable weather, the front shuttering was left until more favourable weather prevailed.

In connection with this work a scheme was inaugurated to preserve the natural amenities of the cliffs. The face of the cliff from the base is retained in position by artificial rockery, and above, where the slope makes its natural inclination, grasses were planted, and after a number of experiments with various kinds, a degree of success has been obtained.

From the top of the cliffs to the Lower Walk, footpaths have been constructed in a pleasing and artistic manner, natural stone rubble walling being built where necessary, and inclined pathways formed with crazy paving.



At Uncle Tom's Cabin an electric lift capable of holding 25 people has been installed, and provision is made for an additional lift when this becomes desirable.

### SOUTH SHORE PROMENADE.

The South Shore new Promenade, opened by the Right Honourable the Earl of Derby, K.G., P.C., G.C.B., G.C.V.O., in October, 1926, is an extension of the Promenade reconstructed in 1905. It commences near the Victoria Pier, and terminates at the southerly boundary of the borough, adjoining the borough of Lytham St. Annes. The works were commenced in 1922 with the construction of an elliptical embayment carried seawards for the purpose of enclosing a sufficient portion of the foreshore for the erection of the Open-air Swimming Bath (completed in June, 1923, at a cost of £85,000).

The sea-wall then continues for 2,420 yards to the southerly boundary of the borough. There are two slades leading to the shore for vehicular traffic, one opposite Watson Road and the other opposite Harrowside, and a number of steps leading from the Promenade to the shore are interspersed along its whole length.

Fig. No. 11 shows a cross section of this Promenade.

The sea-wall is constructed entirely of concrete, approximately 9,000 tons of cement and 80,000 tons of gravel having been used: the whole of the latter material was obtained from the site. The thickness of the wall at its foot is 14 feet, and its necking 5 feet. Old tram rails were driven into the sand as king piles, 8 feet apart, to an average depth of 20 feet, the top being at a level of 7.5 O.D., which is the average level of the sand, and to the rail king piles, walings were bolted with 3 inch close timber sheeting to a depth of 12 feet, to form the toe of the wall.

The wall is about 400 feet westward from the old beach, and, although unsupported, had to withstand exceptionally severe gales during construction, but not a fracture has occurred throughout its length.

Rising about 15 feet above the sand level, a huge area had to be filled up to form the new Promenade: 300,000 cubic yards of sand were taken from the beach immediately north of Victoria Pier, and about 750,000 cubic yards from the sand dunes on the land between the railway and the foreshore. So exposed was the area that, with the heavy seas and high winds, it is estimated that 100,000 cubic yards have been lost by being blown in all directions from the site. On several occasions the sea rose to a phenomenal height (about 5 feet over the normal and expected level) and came over the new Promenade, washing away the foundations of the carriage-way and a small portion of the sunken gardens then in course of construction. These gales added to the cost of the work, as in one case a sum of £1,800 had to be expended to repair the damage. Erosion has also had its effect on the sand at the toe of the wall, and several thousands of tons of old macadam, broken stone, etc., have been placed to a depth of from 2 to 3 feet and 10 to 15 feet from the wall, in order to act as a heavier barrier than the sand. Being more difficult to move, it has had the desired effect.

The original design of the Promenade, as indicated on the deposited plans submitted to Parliament, showed a series of sunken gardens. It was thought

that there would be less sand necessary for the filling up, but it was proved in actual practice that there was no advantage in such a design. The cost of forming and keeping the sand in position was more than would have been the case if it had been brought to the same level. As the sea frequently sprayed over the wall and the palisade, it was necessary to form a protection : otherwise the gardens would be frequently covered with water. The footpath was therefore made 25 feet in width along the edge of the sea-wall, and where sunken gardens were installed a substantial rustic stone-wall was built, broken up by shelters and seating accommodation, and preserving the sunken areas from being flooded except on rare occasions. It is anticipated that in the future sand will accumulate, and the risk of water coming over the wall will be still further reduced.

The first sunken garden was built as a decorative feature. At either end is an ornamental fountain, with a sundial on a pedestal formed by one of the conglomerates found on the shore near the Gynn. It is maintained by the Parks Superintendent with floral beds, and provides a sheltered area for visitors. Each of the three sunken gardens is differently designed—quite distinctive in character, and therefore in some degree easily distinguishable.

The central feature at Harrowside consists of four pylon-formed entrances at the northern and southern ends to a yachting pond. Here children, with their model yachts, are able to derive full enjoyment from that form of recreation. The pond is raised above the footpath surrounding it, and there are two shelters and a colonnade and shelter in the centre. Ladies' and gentlemen's underground conveniences are also provided at this point.

The aim has been to make this portion of the Blackpool Promenade varied in character, artistically attractive, and at the same time amply sufficient to accommodate our numerous visitors. Difficult though it may be to carry out on such a length, with so narrow a width, a design which is not stereotyped, it is hoped that the attempt has met with success.

The separate tram track, which is linked up with the existing Blackpool and Fleetwood tramways, and with the tramways of the Lytham St. Annes Corporation, has a continuous run from Fleetwood to Lytham St. Annes along and near to the sea-front. On the eastern side of the Promenade is a large area of land which has been developed for building sites for hotels, boarding and apartment-houses and private residences. This land has provided exceedingly attractive sites along one of the finest sea-fronts on this coast, with excellent railway and tramway facilities close at hand.

The cost of the sea-wall was £180,000, and the Promenade £110,000, making a total of £290,000.

The whole of the work was designed and carried out by direct labour by Mr. Francis Wood, M.Inst.C.E., the Borough Engineer and Surveyor, who expressed his appreciation of the work done by Mr. H. Banks, the Resident Engineer, and to all under him who so ably assisted in carrying out the work.

#### PROMENADE BETWEEN ARUNDEL AVENUE AND CLEVELEYS.

Perhaps it would be of interest to describe the conditions existing prior to the construction of the sea-wall and Promenade on this length of coast.



Between Bispham and Norbreck the bottom of the cliffs was protected by a rough apron composed of rubble and concrete, which continued a short distance up the face of the cliff, the foreshore on this length having a layer of gravel for a distance of about 100 yards from the bottom of the cliff.

The general level of the gravel at the bottom of the apron on this length was 17 O.D., so it will be realised that in heavy seas the clay face of the cliff was liable to erosion.

From Norbreck to Cleveleys the cliff face was merely sandhills, but the gravel level on this length of foreshore was considerably higher than elsewhere, and thus afforded better protection to the cliff face.

The work of construction of the new Promenade was commenced in August, 1932, and consists of two separate sections. That from Bispham to Little Bispham comprises two separate promenades, the lower one built at a level of 18 O.D., and the higher promenade at a level of 24 O.D., and Fig. No. 12 shows a cross section of this promenade.

This length of the promenade is for the use of pedestrians only, and has no provision for vehicular traffic.

The over-all width of this section of the promenade has a minimum of 55 feet varying according to the slope of the cliff to the higher promenade. The bottom of the cliff is finished off to meet the promenade by means of a rockery wall provided with seating accommodation.

From Little Bispham to Cleveleys, the promenade is at a level of 24 O.D., and is provided with a 30 feet carriage-way, and has an over-all width of 100 feet.

Fig. No. 13 shows a section of this promenade.

At Little Bispham, below the level of the promenade, an underground car-park capable of holding 120 cars has been constructed. This has an over-all length of 300 feet, and is 40 feet wide, and is constructed in reinforced concrete with deck lighting, entrance and exit slides having a gradient of 1 in 10. It is fully equipped with ventilation plant and fire-fighting apparatus. This has proved a distinct success in the bathing season, as the public are thus enabled to park their cars in close proximity to the bathing beach for a moderate charge.

It is also proposed to erect a series of beach chalets, in concrete and brick-work, built into the cliff face south of Little Bispham, and it is anticipated that these will prove a popular amenity.

At Anchorsholme a large pumping station has been constructed below promenade level, complete with pumping plant and screening equipment capable of dealing with 445 cubic feet per second of water from the drainage of the northern part of the borough. At regular intervals along the sea-wall, steps and slides are provided to give access to the beach.

I will endeavour to describe the method of procedure adopted in the construction of this work.

After the line of the wall has been set out, a line of piles composed of old tram rails, 7 inch section, are driven at 8 feet centres. These are called king piles, and they vary in length from 14 feet to 18 feet according to the depth of the clay below the gravel and sand.



When a length of about 50 yards of toe has been prepared in this way, the trench is excavated for the toe wall. This wall, which is 3 feet 6 inches wide, is taken into about 1 foot 6 inches of solid clay, and to form the timber shuttering to the front of the wall a timber waling composed of pitch pine is bolted to the king piles, and close timber sheeting is driven into the clay and spiked to the permanent waling.

At the same time, a trench to form the main wall which supports the bullnose is commenced, and brought up to the correct level by timber sheeting. This wall is 3 feet 6 inches wide, and is taken down 1 foot 6 inches into the solid clay. After a period of three days, the shuttering is struck, and profiles are set up to give the stepping of the apron between the toe and the main walls. The sand-filling to form the apron is then deposited in position, and after this has been thoroughly consolidated 9 inches of 6 to 1 Portland cement concrete is placed on the filling to seal the apron thus formed. The timber sheeting to form the steps of the apron is then placed in position, and 6 to 1 concrete is placed and tamped and screeded to give a suitable finish.

The shuttering for the bullnose is then erected, this being held in position by means of old tram rails let into the apron. Finally, the panelled wall and seating which surmounts the bullnose is erected.

The steel rails which have been used for the construction of the bullnose are cut off to the required level by oxy-acetylene flame. This process is continued in 48 feet lengths, and the average rate of progress attained was 50 to 60 yards of sea-wall per week. At convenient distances bulkhead walls were taken across so that the process of depositing the filling to form the promenade could proceed. This was consolidated by a caterpillar roller, and when a convenient length was completed, the kerbing and construction of the concrete carriage-way and red concrete footpath was proceeded with.

The greater part of the gravel used for the concrete in this work was recovered from the shore, and the filling was also obtained mainly from the sandhills and the shore.

From observation of the foreshore, the level of the gravel adjoining the wall is constantly changing. It has been noticeable that after a severe S.W. gale coinciding with a high tide, the foreshore level has been lowered by as much as 4 feet in some places, so it will be realised that the precautions taken for the protection of the toe, by the construction of the timber sheeting, are necessary.

The length of promenade thus recently completed is 2,940 yards, and the cost of construction £148,000.

The writer would like to express his appreciation to Mr. D. J. Bell, the Resident Engineer, and all under him who so ably assisted in carrying out this work.

In the construction of all these works described, 130 acres of land have been reclaimed from the sea, while the area of the sands at low-water mark of ordinary spring tides is 1,450 acres.

There is no treacherous bottom or quicksand on any part of the foreshore, but during south-easterly winds there is a deposit of river sludge in low places, such as adjoining the piers.

Amongst the most important conditions affecting the design of a coast defence works are, in the author's opinion :—

- (1) A knowledge of prevailing conditions of the foreshore extending over a period of years.
- (2) If accretion is taking place, what is the cause, and from where, and in what manner is the material conveyed to the foreshore?
- (3) Is this beneficial action likely to continue, etc.?
- (4) If erosion is taking place, what is the rate of erosion, and what methods are to be adopted to prevent it, since it is invariably more severe after the erection of a sea-wall?

In the author's opinion, there is less erosion from a wall designed with a flat apron (say 4 to 1, or even flatter), than from any other type of wall, particularly if the apron is stepped in section.

The nearer the design of an apron conforms with the natural formation of the gravel beach at high water level of high spring tides, the less trouble there will be from scour.

## XVII.

# EDUCATION IN BLACKPOOL AND DISTRICT

BY

A. E. IKIN, B.Sc., LL.D.,  
DIRECTOR OF EDUCATION, 1918-1934.

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### INTRODUCTION.

THE educational system of any country at any time is determined to a great extent by the theory of Society held by the people of that country at that time. The educational system of England, which allows for individualism and initiative, is very different from that of Russia, Germany or Italy, where the interest of the State is considered to be superior to that of the individual. Should the external organisation mould the life of the individuals in the community, or should the organisation represent the mind and will of the people? In both Fascism and Communism there is an effort to create a social state of mind by establishing the type of organisation which it is hoped will produce it.

When, in England, in Pre-Norman times there was little differentiation between Church and State, the chief members of the Church being the chief members of the State, when the Church might have been considered as the State in its spiritual aspect, education was provided by the Church for those intended to serve Church or State, and for centuries education was considered



to be a prerogative of the Church. Anyone attempting to found a school independently of the Church was liable to be prosecuted, in early times, before the Ecclesiastical Courts (e.g., Beverley School Case, 1304), or, later, before the King's Court (e.g., Gloucester Grammar School Case, 1410). As Latin was the language in which the Service Books of the Church and the Bible (Vulgate) were written, and as it was also the language of diplomacy, Latin was the chief subject taught in the schools, which later were called 'Grammar' schools.

When the State became differentiated from the Church, when the political aspect became apparently superior to the spiritual aspect of the State, ideas somewhat different from those officially expressed by the Church began to develop, and some attempts were made to deal with education free from the control of the Church; especially after the King's Bench had ruled in the Gloucester Case (1410) that 'it is a virtuous and charitable thing to do, helpful to the people, for which he cannot be punished by our law.' Some schools were founded separately from ecclesiastical influence.

The London grocer, William Sevenoaks, founded Sevenoaks Grammar School in 1432, the master of which was to be 'by no means in Holy Orders.' Similarly, in 1503, the Town Council of Bridgenorth made an order: 'There shall no priest keep no school.'

The Protestant Reformation introduced a new basis for elementary education, namely, the necessity of personal study of the Scriptures in order to secure salvation; and the wider circulation of the Scriptures had been made possible by the development in the arts of Printing. It is 400 years last October (4th October, 1535) since the first complete English Bible was printed.

Under the Puritan regime, during the Interregnum between the death of Charles I. (1649) and the Restoration to the throne of Charles II. (1660), attempts were made to found a State-supported system of education. In 1649 (September 30th, 1649) it was agreed to provide £20,000 (£2,000 of which was for the Universities) chiefly from the first fruits and tenths fund created by Henry VIII. for the salaries of 'preaching ministers and schoolmasters.' It is, however, difficult to say how far this Act was carried out.

It is a strange coincidence that the sum of £20,000 is exactly the same amount as the first Government grant just over a century ago (1833) of £20,000 for Elementary Education.

#### EARLY EDUCATION ENDOWMENTS NEAR BLACKPOOL.

Six years after the 1649 Act just mentioned, a Grammar School was founded at Kirkham, and about the same time, a school was founded at Bispham.

*Kirkham Grammar School.*—Henry Colborne, of London, by a codicil to his will (7th August, 1655) directed his executors 'to purchase a lease of the rectory of Kirkham, and with the profits thereof to purchase and settle land upon the Company of Drapers' for certain charitable uses: from these, £69 10s. was ultimately settled for the maintenance of the Grammar School Master at Kirkham (a University man), and for the maintenance of a second-master and of an usher for the School. These Charities were regulated by a Decree of the Court of Chancery, 12th June, 1673, and the Drapers' Company drew up statutes for the government of the school.



About the same time, the Rev. James Barker, 'to testify his love of his native town of Kirkham,' directed by his will (proved 7th November, 1670), that his executors should purchase lands and tenements sufficient to bring in an annual income of £30, to augment the salary of the schoolmaster, and to make some provision for an exhibition to a poor scholar of the town for his maintenance at the University. £530 was spent in purchasing land at Nether Methop in Westmorland. The value of this property must have appreciated in value. (In 1720 the coppice woods were cut and sold for £630, which sum was invested in the purchase of lands at Kirkham.) A Private Act of Parliament was passed in 1813, authorising the trustees to sell the Westmorland estates (purchased with Barker's money) for the sum of £11,500, and to purchase another estate at Broughton, Preston, for £14,500. (£3,000 was provided by the trustees themselves, who were authorised to take some portions of the estate specified in a schedule to the Act, for themselves, in satisfaction of the sum advanced.) Other endowments in support of this school have been made at various times, including an addition of over 20 acres of land when Fulwood common was enclosed.

*Bispham School.*—Richard Higginson, of St. Faith's, London, founded a school at Bispham, probably soon after 1649. During the period when Cromwell was 'Protector' of England, Mr. Higginson purchased two houses in Paternoster Row, which had belonged to the Dean and Chapter of St. Paul's. (These were purchased from the 'Commissioners for the sale of Dean and Chapter lands.')

By his will dated 25th July, 1659, Mr. Higginson left several sums of money to the parish of Bispham, including a payment of £30 a year, charged on these houses, which was to be used towards the maintenance of a schoolmaster and usher at the school which he had recently founded there. When Charles II. was restored to the Throne in 1660 apparently the property was returned to the Dean and Chapter, for no rents or annual payments could be obtained for the use of the school.

After Mr. Higginson's death, his widow married John Amherst, of Gray's Inn. As Mrs. Amherst did not wish her first husband's legacy to be lost, she, with her second husband, gave £200 to be laid out in the purchase of lands to be employed for the maintenance of 'an able and learned schoolmaster' at the school at Bispham. According to the Returns for 1865-8 there were 36 acres of land then belonging to the school.

As in the case of the Kirkham endowments, the lands so purchased appreciated in value, and at various times authorisation was obtained for the sale of portions of the land (in 1894, £6,000 was received for some of the land) and the proceeds invested in Consols. All lands have now been sold, except the site on which the school stands.

#### CHANGING CONDITIONS.

With the Restoration of Charles II., there was a great change. Those in power were determined, for political reasons, to have no Puritan schoolmasters, and the repressive Conformity legislation followed; and it was ordered that no one could teach without a licence from the Bishop.

These repressive conditions could not last under our British temperament, and the position became easier when the courts of law decided in Cox's Case (1700) that ecclesiastical control did not extend to any schools except Grammar Schools, while in Douse's Case (1701) it decided that it was not a civil offence to keep an elementary school without a Bishop's licence. 'This school was not within the Act of James I., because the Act extends to Grammar Schools, and Douse's School was for reading and writing.' Then Parliament in 1714 definitely exempted elementary schools from the Conformity legislation. As a result, we find many undenominational elementary schools were founded soon after this. About one-third of the whole of the endowed schools in Lancashire were founded about this period, including Lytham School (1702) and Baines' three schools (1717).

### LYTHAM SCHOOLS.

Various sums of money (commencing with £5 from Mr. Threlfall, of Lytham) were given about 1702, the profits whereof were to be employed 'for the only use of poor children's schooling.' About 1720, by an agreement, a sum of £100 was added to the school stock from money which had been raised to repair damage done by a great inundation of the sea. For some reason, the division of this sum among those whose property had been damaged could not be settled, so it was given to the school fund, and put out to interest. Later there were various bequests. Harrison's will (1728) added £60, and by Gaulter's will (1748) over £300 was received, the various monies also being put out to interest. The trustees purchased lands in 1754 and again in 1767 with the funds (including, in addition to other lands in Layton, dwelling-houses and land situated in Blackpool 'near a place called Lane Ends').

As the income from the property increased, schemes for the administration of the Charity were made by the Charity Commissioners, and later by the Board of Education, when the Orders in Council of 1900, 1901 and 1902 (made under the Board of Education Act, 1899) had transferred the powers of the Charity Commissioners, so far as they related to educational charities, to the Board.

In addition to the elementary school at Lytham, another school at Heyhouses (probably at first for girls and infants) was in existence in 1824, and was supported by the Charity. In 1867 John Talbot Clifton (who had provided sites for the rebuilding of Lytham School and for the enlargement of Heyhouses School) gave land at St. Annes for a school there, together with £500; also £125 was given by Lady Cecily Clifton towards the building. Another school, St. John Schools, being in financial difficulties in 1880, the managers appealed to the trustees of the Charity to take over this school. The Charity Commissioners refused their consent, for this was a Church of England school, and the Lytham Charity was undenominational, but the Commissioners authorised a contribution of £100 per annum. In 1896, this school was closed, and later came under the Charity trustees.

As the Charity funds were increasing in value, Sir Amherst Selby Bigge, then an Assistant Charity Commissioner, held an enquiry at Lytham, and ultimately a scheme was made in 1899 for the 'Lytham School Charities,' allowing £450 annually for the three schools—Lytham, Heyhouses, and St.



Annes, with £200 per annum for other elementary schools in the parish, and the rest of the funds for exhibitions, etc.

On 15th June, 1903, a further scheme was approved, which made provision for a public secondary school for boys, under the name of King Edward VII. School, Lytham. On 1st January, 1929, a further scheme was approved, which made provision for a public secondary school for girls, under the name of Queen Mary's School: each of these schools is doing splendid work in the area.

As illustrating the increase in the value of the property in Blackpool (originally purchased by the trustees as agricultural land), the trustees sold to the Corporation of Blackpool, under an order of the Charity Commissioners in 1897, a piece of land about 250 square yards at the corner of Church Street and Abingdon Street, and adjoining St. John's Church, Blackpool, for £1,250 (£5 per square yard), of which £50 was paid to the Church Authorities, as compensation for their interest in certain agreements for leases affecting the land sold. Again, in 1898, the Corporation, acting under compulsory powers, took 1,447 square yards of the Charity lands and paid into court £9,930, the sum found by arbitration to be due (this was at the rate of nearly £7 per square yard, or over £33,000 per acre. As lands were sold, the capital sums were invested in Stock.

The change of value in the Charity funds may be seen from the following details taken from the 'Charity Commission,' or 'Board of Education' Reports:—

#### *Charity Digest of 1865-8.*

Acreage of land, 25½ acres. Former income, £104 18s. Present income, £368 17s. 8d.

#### *Value in 1899.*

Sites and Buildings of St. Cuthbert's, St. Annes and St. John's Schools:

Acreage, 18¼ acres. Rents, £60 7s. 6d. Ground Rents, £624 12s. 1d.

Stock, £1,061 18s. 11d. Dividends, £29 4s.

After paying certain fixed annual charges, the total income was £720 10s. 7d.

#### *Value in 1907.*

Sites and buildings of King Edward VII. School:

Sites and Buildings of three elementary schools, also a school cottage:

£23,476 Stock with an income of .... £832 1s. 7d.

Rents and Ground Rents .... £1,105 12s. 3d.

A total income of .... £1,935 14s. 10d.

(including bank interest).

Together with cash at bank on current

account .... £3,388 9s. 1d.

The cash on deposit was .... £1,097 19s. 9d.



*Value in 1927*

(Before Queen Mary's Secondary School for Girls was built) :—

Sites and buildings as in 1907, with site for proposed girls' school :

£56,899 Stock with an income of.... £2,270 3s. 2d.

Rents and ground rents .... £2,318 0s. 9d.

A total income of .... £4,588 3s. 11d.

Together with cash on deposit in bank .... £13,103 12s. 7d.

What the future value of the Lytham School Charities will be, owing to the increased value of this land in Blackpool, it is not possible to say. There appear to be a number of leases for 99 years (or similar periods), which were granted at comparatively low rentals in the 50's and 60's of the last century, which will terminate during the next 20 or 30 years. The lands will revert then to the Trust, with all buildings erected thereon : and the property can then be leased again at a higher rental. As an illustration of the higher rentals now obtainable, an area of 1,026 square yards was leased in 1922 for 36 years at a rental of £1,000 per annum up to 2nd February, 1930, and £1,600 per annum from that date, whereas a plot of 1,143 square yards was leased in 1851 for 79 years for £11 18s. per annum.

### BAINES' ENDOWED SCHOOLS.

Here we have another group of undenominational schools founded shortly after the date when it was decided that the Conformity restrictive legislation did not apply to elementary schools.

James Baines, of Poulton, by his will (6th January, 1717) left property for the future maintenance of the three schools which he had erected at Marton, at Hardhorn-cum-Newton, and at Thornton.

The Baines' Endowed School at Marton, and the Baines' Endowed School at Thornton, are still elementary schools : the trustees of the Marton school have recently erected new buildings for their school. Funds for this were obtained from land, which had been let for £60 per year, being sold for over £6,000, and the old school buildings at the corner of Preston New Road being sold to the Corporation of Blackpool for street improvement purposes.

As regards the school in Hardhorn-cum-Newton township, a little before 1877 additional school accommodation was required at Staining, and the Education Department suggested that this should be provided from the Baines Endowment, and proposed to make a scheme for dealing with the endowment in this way. The trustees objected, and drew attention to the fact that as the income was over £100 a year, the Education Department had no powers under Section 75 of the Education Act, 1870, to deal with this endowment. The Education Department, after consulting the Charity Commissioners, acknowledged this, and took no further steps with their proposed scheme.

The inhabitants of Poulton and district wanted the funds to be used for a 'Grammar School,' instead of for an elementary school. After an enquiry, the Charity Commissioners approved a scheme in 1880 for this, and the school became Poulton Grammar School. On the grounds that the school had proved its value, when new buildings were required (the endowment being

only about £250 per annum), the Lancashire Education Committee very recently erected a fine new Grammar School to take the place of the old school, and they also assist in providing funds for the maintenance of the school, which is now doing splendid work.

#### ELEMENTARY EDUCATION IN BLACKPOOL.

The motto of Blackpool is 'Progress,' and this has been acted upon in the development of their system of elementary education.

When the 1918 Education Bill was before Parliament, I noted that the Bill proposed to make it compulsory for local education authorities to provide 'central schools' or 'central classes,' for their older or more intelligent pupils.

The Act of 1902 had given powers to provide Secondary Schools, but these had provided for less than 10 per cent. of the pupils in the country. Some of the larger authorities (e.g., London and Manchester) had provided Central Schools to supplement these, and the 1918 Bill proposed that all authorities must make similar provision. I endeavoured to find out how many pupils would be able to profit by Secondary and Central School education, so that I might forecast what provision for these must be made. The Board of Education had no comprehensive statistics with which I could compare Blackpool figures, so I obtained, tabulated, and published particulars of over 600,000 pupils attending elementary schools under local education authorities in various parts of the country. These were published in the *Times Educational Supplement* of September 26th, 1918.

From my examination of the problem, I came to the conclusion that, in addition to providing for about 20 per cent. of the selected pupils in Secondary or Central Schools, it would be essential that centrally-situated Senior Schools should be provided for the other 80 per cent. of the over-eleven pupils.

In 1920, the Blackpool education authority adopted a scheme which I proposed to them for the re-organisation of the Blackpool schools, and the scheme was accepted by the Board in 1920. The scheme was based on the view that if the older pupils who are not selected for attendance at a Secondary or Central School are to have the training which their individual needs and aptitudes require, they must be collected together in schools of such size and with such equipment and staff as may make the necessary curriculum economically as well as educationally practicable.

When the North of England Education Conference was held at Blackpool in New Year week, 1924, the President of the Conference, Mr. Wood (who became Lord Irwin, and is now Lord Halifax) was the President of the Board of Education. Unfortunately he was unable to attend the Conference on account of Cabinet Meetings. (The Cabinet were then considering whether to resign and ask the Labour Party to take their place, and Mr. Ramsay Macdonald first took office as Prime Minister on 22nd January, 1924.)

In the emergency, I could get no one to take Mr. Wood's place, so I occupied the Presidential chair myself, and I gave what was probably the first Conference speech which advocated re-organisation of schools, a policy which is now being so widely adopted throughout the country. I circulated a leaflet to members of the Conference, giving notes on the Blackpool scheme, with particulars of the progress made with the scheme up to December, 1923.



By that date a Central School had been opened, an additional Secondary School had been approved, and, with the sanction of the Board of Education, sites had been purchased for two new Senior Schools for over-elevens, the existing elementary schools to be used as junior schools for those not over 11. This was before the subject had been referred to the Consultative Committee of the Board of Education, under the chairmanship of Sir Henry Hadow.

The 'Hadow Report' was published in 1926, and it recommended the re-organisation of the whole of the elementary schools in the country. Soon visitors from other authorities who were proposing to re-organise their schools, came to see the new Senior Schools which had been erected at Blackpool, especially to see what practical rooms were provided. Among the visitors who expressed appreciation of the schools were Her Grace the Duchess of Atholl (Parliamentary Secretary to the Board), Miss Strachey (Head of Newnham College, Cambridge), and the late Lord Burnham.

Each of the new Senior Schools was built on the quadrangular system, a plan which I recommended to the Sites and Buildings Committee in 1920—class-rooms arranged round a grass court (similar to the arrangement of rooms at the Colleges in Oxford and Cambridge).

There are now three new Senior Schools Departments : Claremont Schools for the North ; Tyldesley Schools for the Central area ; Highfield Schools for the South and South-east of the borough. In addition, the Roman Catholic managers have re-organised their schools in the South part of the borough, having erected a new Senior School (mixed) to which pupils from St. Cuthbert's Junior School, and St. John Vianney Junior School are transferred between 11 and 12.

The Blackpool Education Committee spent over quarter-of-a-million pounds on building new schools during the last 10 years that I was Director, and still have an extensive building programme to carry out.

Two years ago the borough was extended by the addition of a rapidly-growing area. As the Lancashire Education Committee had been expecting for some years that this area would be added to Blackpool, they had built no new schools in that district, and the Board of Education are now pressing the Blackpool Committee to build schools for these pupils, and two sites have been purchased in the area. In addition, building is progressing in other parts of the borough. The numbers on the books in October, 1931 (when the economy regulations of the Board of Education caused a slackening off of the building of new schools) was 9,899. At present (May, 1936) the numbers are 11,226, an increase of 1,327 pupils to be provided for.

The Blackpool Education Committee have for a number of years taken a keen interest in the physical training of their pupils (especially swimming), and have had a physical exercise organiser during the last 18 years. The teachers of the schools, being so keenly interested in the well-being of their pupils, and having their own sports and other committees, have co-operated with him with beneficial results to the pupils. Annual swimming galas are held by some of the individual schools in the borough, also a public swimming gala is held at the large Open-air Baths, in July, open to pupils from all schools in Blackpool, whether independent or rate-aided or supported. An indoor gala for elementary schools is held at the Tower (sometimes there are nearly



3,000 spectators). Special areas in the fine Stanley Park have been prepared for use for organised games by the schools. Negotiations are now in progress for the purchase of additional playing fields.

A fine medical and dental clinic has been erected, and with its efficient medical and nursing staff, and its two full-time dental surgeons with attendants, the health of those who on medical inspection show need of preventative or ameliorative treatment, receives highly skilled attention.

After the Hadow Report was issued, the Lancashire Education Committee began to deal with the reorganisation of their elementary schools, and recently two new Senior Schools have been opened in their area, so that the elementary schools of Fleetwood, Thornton Cleveleys and Poulton are now re-organised as well as the Blackpool schools.

### SECONDARY SCHOOLS.

As the 1902 Education Act gave local education authorities for higher education power to provide Secondary Schools, on 1st October, 1904, the date on which Blackpool became a county borough, the foundation stone was laid for a Secondary School (now the Blackpool Grammar School), which provided a sound secondary education for pupils from Fleetwood, Cleveleys, Lytham and St. Annes, as well as for Blackpool pupils.

In 1921, I became rather perturbed at the waste of time and mental energy of the growing number of pupils who travelled night and morning from Fleetwood to this school, and thought it would be far more advantageous for these pupils if there were a Secondary School at Fleetwood. I discussed the question with the Chairman of the Governors of the Blackpool School, and he agreed with me. As a result, we arranged a meeting with the then Chairman of the Lancashire Education Committee and the Director of Education for Lancashire to discuss the matter. The Lancashire representatives were of opinion that the time was not opportune, and, further, were of opinion that there would not be sufficient pupils in Fleetwood to support a school.

However, being anxious for the pupils who had to travel, and believing that the supply would create the demand, we insisted on the provision of a school at Fleetwood, and to ensure this we stated definitely that in 18 months' time Fleetwood pupils would be excluded from the Blackpool school. They then agreed to recommend that the Lancashire Education Committee erect a Secondary School in Fleetwood. In order to assist them as regards numbers, we agreed that after the Fleetwood School was opened, we would not admit any pupils to the Blackpool Secondary School from any part of the county area north of Blackpool. As a result of this, the Fleetwood Grammar School was erected, and this has proved so successful that considerable enlargements have been necessary.

It seems rather ironical, after our promise to assist their numbers by refusing admission to the Blackpool School of pupils from the County area, that a few years later, in a committee room of the House of Lords, I heard counsel for the opposition to a proposed extension of the Blackpool boundaries give as a proof that Blackpool did not cater so well for the educational needs of the area proposed to be added to Blackpool as the Fleetwood Grammar School

did, that no pupils from Cleveleys or Thornton were in attendance at the Blackpool School.

As part of the Blackpool 1920 educational re-organisation scheme, and in view of the increasing number of children of school age, an additional Secondary School was provided. The (mixed) Secondary School erected in 1904, became the Blackpool Grammar School (for boys), and the new school is called the Girls' Collegiate School.

Both of these schools are doing splendid work. There is a steady flow from both schools to the Universities. At the present time, there are 44 boys from the school in attendance at Universities (15 at Oxford or Cambridge). Numerous scholarships have been obtained by their pupils (including an open scholarship for Newnham College, Cambridge, from the Collegiate School).

The Roman Catholic Education Authorities have also provided two Secondary Schools in Blackpool which cater not only for Blackpool pupils, but also for boarders from all parts of the country.

The Layton Convent Secondary School (for girls) is now one of the most up-to-date Roman Catholic boarding schools in the North of England (about £15,000 has been spent recently in improving the general amenities of the school).

The St. Joseph's College (for boys) caters similarly for boys. Both of the new Roman Catholic schools are grant-earning Secondary Schools under the inspection of the Board of Education, and the Blackpool Education Committee nominate one-third of the governors of each school, and make a grant of £2 per term for each Blackpool pupil over 11 years of age.

In addition to the excellent provision of State and rate-aided Secondary Schools, there are several good independent schools (or private schools) in the district, which take boarders as well as providing for day pupils.

For boys there are :—Arnold School, South Shore, Blackpool ; The High School, Alexandra Road, Blackpool ; Cleveleys College, Cleveleys ; Lawrence House, St. Annes-on-the-Sea.

For girls there are :—Arnold High School for Girls, South Shore, Blackpool ; Elmslie Girls' School, Whitegate Drive, Blackpool ; Northlands High School, Springfield Road, Blackpool ; Terra Nova School, Forest Gate, Whitegate Drive, Blackpool ; Highfield College, Norbreck, Blackpool.

Of the above schools, three are recognised by the Board of Education as efficient schools : Arnold School, Arnold High School for Girls, and Elmslie School. Some of these boarding schools, which take pupils up to the Higher School Certificate standard, and fill a definite place in the educational life of Blackpool, are becoming increasingly as well known in the North of England as in the immediate district itself.

#### ROSSALL SCHOOL.

In addition to the various schools already mentioned, there is the well-known Public School situated on the coast, about a mile north of the Blackpool boundary.



Rossall School was founded in 1844, with the object of providing an education of the highest grade for sons of clergy and laity at a moderate cost. The school is incorporated by Royal Charter, and is under the management of a Council. It stands close to the sea in a healthy, bracing situation. The President of the Governors is the Earl of Derby. The general and special education is intended to cover the needs of those destined for the Universities, the Army, the Navy, the Air Force, the Civil Service, the professions, or a business career.

The school contains a Classical Side and a Modern Side, and there is also a preparatory school. The school has received the formal recognition of the Army Council, after inspection by the Oxford and Cambridge Board ; also of the Royal College of Physicians and Surgeons, and the General Medical Council. It is fulfilling a useful function in the educational life of the country.

#### TYPES OF EDUCATION PROVIDED BY BLACKPOOL EDUCATION COMMITTEE.

As regards the types of education provided, it may be noted that formerly it was only possible to obtain education beyond the School Certificate or Matriculation standard by attendance at a University or at a College of University standing. Now at the Blackpool Grammar School there are advanced courses of the following types :—

- (a) A special course of Further Education of Post School Certificate standard for boys who will not go to a University, but will make business or commerce their life work.
- (b) A special course for those boys who wish to take up engineering as a profession. (When the Technical College is open, these boys will be able to attend at the engineering workshops there on certain mornings during the week.)
- (c) A special course for boys who wish to enter a University with the view of entering what are commonly called 'the learned professions,' or of entering the Civil Service.

There is a Special Course in Economics (this should be of interest to the British Association, as one subject for discussion is Economics in Secondary Schools), and a course in Biology specially suitable for those who may later wish to enter the medical profession.

In the Collegiate School for Girls there are special courses of further education appropriate for those girls who wish to enter a University or a College. Also, there is a special course available for girls over 16 who wish to develop their education on the Domestic side ; the cookery and laundry work, with the Domestic Decorative Arts work, are specially worthy of commendation.

The Palatine Central Boys' School provides a special course for the last two or three years of the school life of the boys who wish to develop on the commercial side, including book-keeping, shorthand and typewriting. A parallel course of Practical Science, including a good course in Practical Mechanics, with wood or metal work, is available for another group of boys. When the Technical College is open, the boys will be able to make use of the chemical and physical laboratories there on certain mornings during the week. A number of boys from this school pass the School Certificate examination each year.



In the Palatine Central Girls' School there are also two parallel courses available after the first two years in the school. There is a Commercial Course, similar to that for the boys. There is also a special Domestic Course for girls from 13 to 15 or 16, including cookery, laundry, dressmaking, millinery, and various Domestic Arts and Crafts.

For the centrally-situated Senior (or Modern) Schools, in the boys' schools, a practical education is given to train the boys to be handy men and to be adaptable. In the girls' schools, the life and health and work of the home is the basis of the instruction.

Household Economics is the central subject of the curriculum for the girls, other subjects being taught with special reference to their bearing on this subject, e.g., 'Geography' may deal with the places from which the various materials required in the house are obtained, whether for food or clothing or cleaning, and with parts of the Empire, to which girls may usefully emigrate; 'Arithmetic' may deal with costs of materials, or articles required for furnishing the home, for food, for clothing, or cleaning (e.g., cost of a dress or hat made by a girl), rent and rates calculations, insurance payments (for sickness or other misfortune), also household accounts should be included (e.g., weekly budget of house). 'Drawing' may be taught in connection with handwork, whether garment-making, millinery, or work in domestic arts and crafts. Simple lessons in appreciation of form and colour may be included.

History and Literature may be taught, so as to give an interest in the life of the community, thus preparing for the wise use of leisure. Girls should be encouraged not only to read, but to understand and talk about happenings in the world around, so that they may be better prepared to take part in civic life as well as home life.

Household Economics may be taken to include :—

- (a) Elementary Human Physiology and Hygiene, including the care of infants and sick nursing.
- (b) Chemistry and Physics of the household, including common materials used in the household for cleaning and other purposes, heating and lighting of the house, comparative warmth-retaining properties of clothing materials, relative food values, methods of food preservation (curing, pickling, bottling).
- (c) Household management: Planning out the work of the house, cleaning, practical cookery, practical laundry.
- (d) Household arithmetic and accounts.
- (e) Varied forms of handwork: needlework, millinery, soft furnishings, arts and crafts in the home.

#### EVENING INSTITUTES.

Evening Institutes are provided to afford young people an opportunity of continuing their education after leaving the day schools. Graduated courses of instruction, extending over two years lead up to the examinations of the Union of Lancashire and Cheshire Institutes, and prepare for more advanced work at the Technical College or at the Palatine Central Commercial and Domestic Evening Institute.

Among other types of work, special courses are provided for persons preparing for the examinations of the Institute of Certificated Grocers, both for the Associateship Diploma and for the National Diploma; also for the examination of the Meat Traders' Association Diploma, thereby enabling pupils to qualify for higher positions in these respective businesses.

Men's and Women's Institutes (for adults only) are provided chiefly for recreational occupation in woodwork, metal-work, domestic subjects, or hobbies, but with no examination at the end of the course.

Some very useful Recreational Courses are provided at three centres for young persons by a voluntary organisation, the Education Committee allowing the free use of school buildings with heating and lighting, and also make a grant of £90 per centre towards the maintenance cost.

When the Board of Education Regulations (in 1924) authorised grant-in-aid of such courses, it was apparently intended at that time that these should be provided by voluntary organisations, and not by the local education authority, and Blackpool Education Committee made a grant in aid of two such centres. Later, the Blackpool Rotary Club decided for one year to aid a third centre, and now, as mentioned, the Education Committee aid all three centres.

The Blackpool Education Committee aid the Workers' Educational Association by allowing free use of school buildings, with heat and light, and by a grant-in-aid of each Tutorial Class; Literature, Zoology, Economic Geography, History of Civilisation, Psychology and Philosophy, Astronomy and Physics are among the subjects taken.

In addition, the Blackpool Education Committee have, since 1919, published annually a 'Prospectus of arrangements for adult education,' giving the programmes of the varied types of educational opportunities (lectures, etc.) provided by the different voluntary organisations in Blackpool, so that the citizens of the borough may see what educational facilities are available, and that each may have an opportunity of selecting that particular form of intellectual employment which appears to be most suited to his or her particular needs.

#### BLACKPOOL TECHNICAL COLLEGE.

When the Blackpool Secondary School was built, arrangements were made for that building to be used for evening classes, as a Technical School. On account of the number of houses being built, the chief type of work to be catered for at that time was the building industry. A work room was provided in the basement of the school for carpenters, one for painters and decorators, one for building science, with a really useful plumbing laboratory.

As the town grew, other classes became necessary, and courses in electrical engineering and mechanical engineering were introduced. Later a motor mechanics' course was included, in addition to which the chemistry and physics laboratory of the Day School were used for other classes, as well as the Art Rooms, and in time the school became over-crowded. The domestic science classes were transferred to the Palatine School, and various temporary alterations made to some of the workrooms. At last it was recognised that, in spite of makeshift transformations of rooms, it was impossible to provide satis-



factorily for all the needs of the district, especially as through the co-operation of employers there was a growing need for day classes for apprentices.

A Technical College is now in process of erection. The passing of the plans for this and the acceptance of tenders for building was one of the last pieces of work for which I was responsible before retiring from my work as Director of Education, and after striving for years to obtain a Technical College I had the satisfaction of personally digging the first sod for the building.

The foundation stone was laid by the Earl of Derby in September, 1934. The College will serve for Technical work and as a School of Art. The Technical College will be one of the most useful educational institutions in Blackpool and the district around. It will be linked up with so many different phases of educational activity.

The engineering students from the Grammar School may attend for Technical Instruction in the engineering laboratories and workshops on certain mornings in the week. The Palatine Central School Boys, on the practical side of the school, will be able to supplement their training in Practical Mechanics by work in the chemical and physical laboratories of the College on certain mornings of the week. Pupils from the Collegiate Girls' School may attend special commercial courses after taking the School Certificate at their own school.

The chief industries of Blackpool will be specially catered for at the Technical College, or in the Palatine Schools adjoining. Those engaged in the accommodation and catering for visitors will have special facilities for improvement. The grocers and provision dealers, the butchers and meat traders, the bakers and confectioners who provide foods for visitors, will have special courses to assist them to carry out their work efficiently, and thereby ensure a plentiful supply of food materials of a good quality. They will be taught how to recognise good quality in their respective foodstuffs. Those who prepare the foods so provided may have special day cookery courses during the winter months when the visitors are fewer. There may also be day classes in dress-making, ladies' tailoring and millinery during the winter months. The apprentices or improvers engaged in the building trades or in engineering work will have opportunities to obtain instruction correlated with their every-day work in Evening Classes, and with the co-operation of the employers afternoon classes will also be provided. Those engaged in the motor repair shops, or at garages, will find help for their work in the motor mechanics' classes, and the increasing number of persons required to execute minor repairs to Radio Receivers will have a training provided in the new radio engineering workshop.

### CONCLUSION.

Blackpool and the surrounding district are well provided with educational facilities of various kinds, in addition to there being a Public School, Rossall School, in the area. There are many beautiful new re-organised elementary schools, both Junior and Senior Schools, with others in process of building, to provide for the increasing child population (not decreasing, as in some areas).



There are Central and Secondary Schools provided by the Education Committee, both types supplying an efficient education : in the Palatine Central Schools to 15, and in the Secondary Schools to 16 or 18. There are numerous scholarships for capable pupils from the Elementary Schools to these schools. There are the two Roman Catholic Secondary Schools, and good private (or independent) schools in Blackpool, giving a sound secondary education. There are the Fleetwood and the Poulton Grammar Schools in the area to the north of Blackpool, and the two Secondary Schools of the Lytham Charities in the area to the south of Blackpool.

There are valuable scholarships open to competition to Blackpool pupils, to enable pupils to pass to the Universities or to an engineering college. (11 such scholarships were taken up in October last.)

There are the Junior Institutes for the continuation of education of those pupils leaving the Elementary Schools who wish to progress further up the educational ladder ; there are also the various recreative centres for those young people who require leisure time occupations.

There are varied opportunities in the Adult Evening Institutes, and, through the work of the voluntary organisations (W.E.A., etc.), for an intellectual use of the leisure of adults, both men and women.

The Technical College, with the Palatine Commercial and Domestic Central Institutes, provide opportunities for those who, after acquiring a taste for further practical work in the workrooms of the re-organised senior or central schools, and in the Junior Institutes, or whose daily avocation necessitates further study, and further education. Each may find in Blackpool those educational facilities which life demands for work or for leisure, from the age of five to 60.

The new Blackpool Technical College will become what has been styled 'The Workers' University' for the whole of the Fylde area, including the borough of Fleetwood, the borough of Lytham St. Annes, the urban district of Poulton, the urban district of Thornton Cleveleys, as well as for the county borough of Blackpool.

The climate of Blackpool and district is ideal for boys and girls. Youth thrives in its glorious air, and responds physically and mentally to its exhilaration. The breezes from the sea are famed for their ozone and their bracing effect on the growing child, while the wealth of sunshine, the low rainfall and the general absence of fog, all tend to produce an atmosphere as healthy as it is invigorating. As a result of this (especially as the L.M.S. Railway Co. provide a good service of business trains to Manchester, etc.), there is an increasing number of people who are taking up residence in Blackpool and the immediate district in order that their children may enjoy the benefit of the excellent schools and the wonderful climate.

N.B.—Since the foregoing Article was written the Board of Education has agreed to recognise Arnold School for Boys as a Grant-earning Secondary School from August 1st, 1936.

## XVIII.

## WATER SUPPLY

BY

JOHN HALL,

CLERK AND SOLICITOR TO THE FYLDE WATER BOARD.

BLACKPOOL is in the happy position of having an ample supply of water of excellent quality and high chemical and bacteriological purity.

The water supply only dates back to 1864. It was commenced by a private company known as the Fylde Waterworks Company. The undertaking was afterwards purchased by the present water authority, the Fylde Water Board, specially incorporated for the purpose, the headquarters being in Blackpool.

The Fylde Water Board was constituted by Act of Parliament in 1897, and comprises representatives appointed by the County Borough of Blackpool, the Boroughs of Lytham St. Annes and Fleetwood, the Urban District Councils of Thornton Cleveleys, Poulton, Kirkham and Preesall and the Rural District Councils of Fylde and Garstang. Blackpool has 10 representatives, Lytham St. Annes five, Fleetwood three, and the District Councils one each.

The original sources of supply (the Calder and Grizedale Watersheds) are situated on the western foothills of the Pennine Chain about five miles north-east of Garstang. The area of these watersheds is 3,083 acres. They consist of a wide expanse of moor on the millstone grits. The average rainfall is 47 inches. The Calder and Grizedale streams are tributaries of the River Wyre, and the water is impounded in reservoirs at Barnacre.

The Board's water supply area covers an area of over 207 square miles. It is bounded on the south by the River Ribble, on the east by the foothills of the Pennine Chain, and on the north and west by the sea.

The Board are, however, under statutory obligation to provide bulk supplies for a further area of 112 square miles. These two areas amount to about one-sixth of the area of the County of Lancashire.

Applications for supplies rapidly came forward from the inception of a water supply system in the district, and the Company never succeeded in overtaking the enormous demands made upon them. The Fylde Water Board acquired the undertaking in 1899, and until recent years they have had a continual struggle to meet the ever-increasing demands of the rapidly-growing population. The aggregate capacity of the reservoirs taken over by the Board at the transfer of the undertaking was 220 million gallons. Foreseeing the need for additional storage accommodation, the Board, in 1903, commenced the construction of a new reservoir at Barnacre (Grizedale Lea) with a capacity of 284 million gallons.

Unfortunately, the construction of this reservoir occupied a long number of years owing to many difficulties of a geological and engineering nature, and



to stoppage of work in consequence of the War. It was officially opened by the then Chairman of the Board on the 30th August, 1922.

In 1910 the Board obtained an Act of Parliament authorising the construction of several works, such as the Warbreck Service Reservoir and Water Tower, which better utilise their Barnacre watershed.

The continued and prospective development of the Board's district, particularly the sea-coast resorts of Blackpool, Fleetwood, Lytham St. Annes and Thornton Cleveleys made it apparent that the Barnacre watershed was quite inadequate to meet the growing needs. The Board, therefore, determined to secure an entirely new and larger source of supply. In 1912 they obtained Parliamentary powers to acquire an important watershed on the River Hodder, a tributary of the River Ribble.

As soon as the embargo on capital expenditure was removed, after the conclusion of the War, the Board commenced operations upon their new Stocks Reservoir on the Hodder watershed. This watershed lies in the Pennines in the West Riding of Yorkshire, to the north of Slaidburn, and about 10 miles from Clitheroe.

The area of the watershed is 9,259 acres. It consists of moorland, rough pasture and meadow, and is situated on the Bowland shales and Pendle grits. The average rainfall is 60 inches.

In this area the River Hodder has its source. The head waters of the river and its tributary streams are impounded in the Stocks Reservoir, which has a capacity of 3,059 million gallons. The water is of excellent quality.

The Stocks Reservoir and comprehensive Hodder supply scheme was inaugurated on July 5th, 1932, by H.R.H. Prince George, K.G. This marked the culminating point of many years of endeavour and unremitting labour, and placed the Fylde Water Board in the satisfactory position of being able to meet all demands that might be made upon them, however great the influx of visitors during the holiday season.

## XIX.

# THE VERTEBRATE FAUNA OF THE BLACKPOOL DISTRICT

BY

J. R. CHARNLEY.

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ALTHOUGH few English counties surpass Lancashire in diversity of physical features, few counties, nevertheless, have suffered more change from the hand of man than Lancashire. Especially is this so as regards the southern portion. Despite the gradual expanse of a dense population and the ever-increasing demands of modern commerce, however, there are still great tracts of country



in the north of the county which retain their primitive conditions, and where the fauna has, in all probability, undergone relatively little change since its establishment there.

There is no question, however, that conditions on the whole have changed considerably during the last few decades. The mosslands are slowly but surely vanishing under the hand of the agriculturalist ; the sand-dunes, with their interesting littoral fauna and flora, are fast disappearing before the operations of the builder, the ubiquitous golfer and the foreshore improvements by the various watering-places ; modern farming cuts everything clean and close, and the old-fashioned stubble, with its ample covert, no longer exists ; roads and pathways are altered ; hedges are trimmed in such a fashion as to afford little or no shelter for nesting birds ; while poultry, so extensively farmed to-day, are not only the means of carrying disease to what were hitherto clean and healthy fields, but they are often turned on to the stubbles after harvest to glean the food which was formerly the fare of the Partridge and other granivorous species.

Although these factors have told adversely on certain sections of the feathered community, notably on some of the smaller passerine species, individuals of other species have increased considerably and are more firmly established than ever, so it is probably no over-drawn statement to say that to-day the bird population, as a whole, is, numerically, little affected by the so-called march of civilization. Moreover, the gradual decline of game preserving in some localities has happily led to an increase of raptorial and other harassed species usually figuring on the gamekeeper's gibbet ; while bird-watching—as opposed to bird collecting—which is growing in popularity, is having, in conjunction with protective legislation, a beneficial effect on the avifauna in general and on the rarer members of it in particular.

In considering the district as defined for the purposes of this article and its relation to the distribution of its fauna, it may be conveniently divided into three main divisions.

The western division, known as the Fylde, lying between the Ribble and Lune, and penetrated mid-way by the Wyre, is broad and flat, with slight undulations here and there, but entirely lacking hills of any altitude. This area is in a high state of cultivation, and is diversified throughout by an abundance of hedges, shrubberies, orchards and belts of woodland which form the haunt of numerous finches, warblers and other small birds. The sadly-reduced mosslands are mainly confined to the Pilling, Cockerham and Winmarleigh districts, in one of which the Short-eared Owl, Nightjar and other species still find a nesting sanctuary. 1913 saw the last of the large Black-headed gullery which had been established at Cockerham Moss since 1876, the birds having been driven out by the activities of the Fylde Peat Moss Litter Company. A feature of the landscape, likely to attract the attention of the stranger to these parts, is the stunted and desiccated appearance of the trees, a peculiarity caused by the prevailing winds and noticeable almost as far inland as Garstang.

The eastern division consists of elevated barren moorlands with deep-wooded glens, bordered below by upland pastures and the low land fringing the rivers. Here nest the Ring Ousel, Twite, Merlin, Curlew and Golden Plover ; while some idea of the number of Red Grouse which these moors support, may be

gathered from the fact that the record British grouse bag, consisting of 2,929 birds, was made on the Abbeystead range on the 12th August, 1915; and before the end of October following the total bag exceeded 15,000 birds.

The northern division is separated from the remainder of the district by the Lune, and its tributary stream, the Wenning, and has Westmorland on its northern boundary. This area is more varied geologically than the other divisions, its scenery being variegated by limestone outcrops, crags and scars, wooded slopes and large tracts of pasture-land.

Not the least important feature of the district from a faunistic standpoint, is its extensive coastline with its vast expanse of sands and mudflats. These latter are at all times attractive to wildfowl and waders, and during severe spells of weather when the birds are driven from more inland situations to seek the open waters of the foreshore, astonishing numbers of wildfowl assemble and a constant fusillade is heard from the fowling-pieces of the neighbouring gunners.

It is during spring and autumn, however, when the great waves of migration have set in, that they present their greatest attraction, though the geographical position of the district renders it less favourable as a calling-place for migrants than those of the eastern and southern counties. At such times the numerous estuaries of the Lancashire coast, with their adjoining marshes, covered in parts with a profusion of coarse grass, Sea Thrift, Sea Aster and other saline-loving plants, and teeming with different forms of marine life, afford a congenial resting-place and an abundant feeding-ground for all kinds of shore birds.

In spring various waders, some showing the pectoral patch of summer, visit the estuaries for rest and food on their journey to the north. In August the birds begin to move south, the birds of the year invariably arriving before their lingering progenitors, and there is a succession of individuals until late in October. The marshes indeed are seldom without signs of bird-life, for even when at times they seem forsaken by ducks and waders there are always small parties of gulls to be seen passing up the rivers and retiring seaward at night. In summer too one occasionally sees flocks of waders which from some cause or other have failed to join their fellows in the spring migration to breeding-grounds a thousand miles away within the Arctic Circle.

The almost total lack of rocks on the Lancashire coast accounts for the absence of many common sea birds as breeding species. There is, however, along considerable portions of the coast a belt of shingle amongst which nest the Ringed Plover, the Oystercatcher and, more rarely, the beautiful Little Tern.

A good deal of information bearing on the local fauna has been published from time to time, much of which is referred to in the excellent series of bibliographies printed in 'The Naturalist' for 1884 onwards; and in 'The Geographical Bibliography of British Ornithology,' by Mullens, Swan and Jourdain (1920).

There are few noteworthy collections in the district. The Harris Museum, Preston, contains some interesting palaeontological exhibits and a fairly-representative collection of British Birds, as well as the recently-acquired Frohawk collection of eggs, nests and skins. The admirable village museum



at St. Michaels-on-Wyre, founded nearly fifty years ago by Mr. H. P. Hornby to illustrate the history and natural history of the Fylde, contains many specimens of local interest.

In the more general survey which follows, it has been deemed advisable, for considerations of space, to dispense with scientific names. As the classes under review are familiar to the average reader, it is hoped that no inconvenience will be caused thereby.

### MAMMALS.

Although published records of osteological remains discovered in the county are comparatively few, they are such as to show that Lancashire possessed an interesting prehistoric fauna, including such animals as the Elephant, Lion and Hyena, though these apparently had become extinct before man had arrived in the county. The Urus, or Wild Ox, was obviously plentiful, for the largest number of skulls and horns of this animal ever found in Britain were unearthed, along with a large number of other mammalian remains, during the excavation of the Preston dock in 1885. These numbered approximately 80. Curiously enough none of these skulls bore any trace of injury, and it has been assumed, therefore, that the animals were entombed at one and the same time as the result of some prodigious storm. The configuration of the Ribble valley, as pointed out by the late Johnathan Shortt, is such that it would only require a comparatively slight obstruction to keep back for a time the river waters so as to form an enormous reservoir to be poured forth as a devastating flood on the removal of the barrier.

During historic times vast tracts of unreclaimed forest-land existed at Bowland, Rossendale and Pendle, affording for centuries an impenetrable retreat for the Wolf and Wild Boar. The Wolf became extinct in England during the reign of Henry VII. and one of its last strongholds was Bowland Forest. Wild Boars are recorded at Hoghton Tower in 1617, at which time their range probably extended north of the Ribble. The last herd of aboriginal Red Deer was destroyed at Bowland in 1805.

The existing mammals present few noteworthy features, and further research is essential before we have an adequate knowledge of the local status of some of the smaller species, especially of the Bats.

Of the Insectivora, the Mole, Hedgehog and Common Shrew are frequent and generally distributed; the Lesser Shrew is met with sparingly, but, no doubt, is often confused with the Common Shrew.

The Chiroptera include four species, of which the commonest is the Pipistrelle. The Noctule and Long-eared Bats occur, the latter with some frequency. An example of the Whiskered Bat was caught at Lytham in 1888, and the species is also recorded from Mytton on the Yorkshire border. Daubenton's Bat probably occurs, though (presumably) still unrecorded.

As regards the local Carnivora, the Pine Marten has long been extinct; and what would appear to be the last local Polecat was killed in the Fylde many years ago. The Stoat and Weasel abound and are universally distributed. The Badger has forsaken its old haunts and appears to be extinct except as a very occasional straggler from other parts. The Fox is found in small numbers



on the hills and, incidentally, appears in the lower country. The Otter is tolerably common in the streams. Two were shot, respectively at Marton and Warton in the early part of this year (1936). A record of special interest is that of a female Wild Cat which was shot near Carnforth in the autumn of 1922. A male was also shot, but escaped. Both no doubt were strays from over the border.

The Lancashire coast, being destitute of rocky caverns, is hardly suitable for Seals, but the Common and Grey Seals are in all probability casual visitors. An example of the Harp Seal was shot in Morecambe Bay in 1868.

The local list comprises 10 rodents. The Bank, Field and Water Voles are common, as is also the Wood Mouse. The Dormouse has occurred in the Brock and Hodder valleys, but little appears to be known of its present status in those parts; very likely its retiring habits often cause it to be overlooked. The Black Rat is confined to the port towns, and at Preston dock it outnumbers the brown pest by approximately three to one. The Red Squirrel is thinly distributed in the more easterly portions of the district, but is commoner north of the Lune. Various reports that the alien Grey Squirrel has recently arrived on the north bank of the Ribble require confirmation.

The Irish Sea lies off the customary migration route of most Cetaceans, but the Porpoise, the Common and Bottle-nosed Dolphins and the Bottle-nosed Whale have appeared off the Lancashire coast at various times, or have been stranded in the estuaries. The Killer has been reported (without data) but may be more frequent than is supposed. The White-beaked Dolphin occurred at St. Annies-on-Sea in 1911.

#### BIRDS.

Lancashire is relatively rich in bird-life, for, apart from its attractive topographical features, its maritime situation gives it a marked advantage over any inland county, however large, and makes it especially rich in passage migrants. Owing to the difficulties of accepting or rejecting doubtful records, however, the number of species which have occurred within the county limits cannot be stated with strict accuracy, but it may be put down as approximately 270. The Blackpool list for the area under consideration numbers about 240, more than half of which are regular visitors.

Although much useful information regarding the local movements of birds, has, of late years, been furnished by a few competent observers in various parts of the county, our knowledge of the volume and frequency of west coast migration is still imperfectly understood, but will very likely, on further investigation, be found to be of more significance than is at present supposed. Only those who are accustomed to accumulating facts on any special branch of zoology have any real conception of the amount of information to be gained by regular and systematic observation. Especially is this true as regards ornithology, and what is largely needed at the present time to grapple with some of the problems of bird-life which still bristle with difficulties, is an increase in the ranks of reliable observers.

It is no easy matter to define the exact status of every species known to occur within the limits of a district such as the present, owing to the fact that there is so much ground to cover in comparison to the scanty number of

competent observers available for working it ; or, to put the matter in another way, there is so much room in which to miss, or overlook, an apparently rare or local species, individuals of which may actually be more numerous, or more widely distributed, than present observations imply.

A comprehensive account of the local avifauna being impossible within the limited space allotted to this article, the following brief summary will, it is hoped, serve to give a general idea of the birds which occur in the district :—

The list includes six crows. The Raven pays occasional visits to the Pennines ; it nested in Bowland in 1886, and has attempted once or twice to do so since. The Carrion Crow, never a common species, appears to be, if anything, slightly on the increase. The Hooded Crow, which was described by some of the older writers as a common winter visitor, is nowadays seldom met with. The Rook and Jackdaw are abundant. The former has developed a tendency to nest in smaller colonies, which, however, are not always permanent settlements. The Jay and Magpie are holding their own. The Starling, like the House Sparrow, already far too plentiful, is rapidly increasing. During winter it congregates in vast hordes and retires at sundown to various common roosting-places. The Rose-coloured Pastor has been shot at Lancaster, and the Golden Oriole at Chipping.

Finches and Buntings number 17, some of them still common, others much reduced in numbers. The Hawfinch is now rarely seen, though not uncommon at St. Michaels-on-Wyre and other places 40 years ago. Modern farming and bird-catchers have thinned out and almost banished the elegant little Goldfinch. Small flocks of Bramblings haunt the beech woods in winter and are often seen on the coast. The Siskin is less common than formerly ; it is reported—on rather slender evidence—to have bred near Lancaster in 1863. The Tree Sparrow breeds sparsely, but is nowhere numerous. The Lesser Redpoll is not uncommon as a nesting species, but like the Linnet and a few other finches is more generally dispersed in winter. The Bullfinch is local, and as a breeding species is restricted to a few localities, mainly in the neighbourhood of Garstang. The Crossbill has occurred during sporadic invasions.

The Reed and Yellow Buntings, although still plentiful about swampy spots and tangled hedgerows, where these exist, are not so abundant as formerly. The Corn Bunting, never a common species, is nowadays seldom met with. Parties of Snow Buntings visit the hilly and maritime portions of the district during winter, and occasionally stray to inland localities, where they consort with Larks and Linnets. Mitchell ('Birds of Lancashire') mentions an immature Lapland Bunting said to have been shot near Preston in 1833.

The Woodlark, considered at one time a not uncommon resident in the Ribble and Wyre Valleys, has not been encountered for many years and is probably extinct. Recent reports of its occurrence locally are probably due to confusion with the Tree Pipit. A Shore Lark was shot at Oxcliffe, near Lancaster, in 1899.

Five Wagtails and four Pipits are included in the list. The White Wagtail occurs regularly on passage in spring and autumn ; and although the records of the Blue-headed are few, the bird is probably more frequent on passage than at present imagined.



Both the Tree and Meadow Pipits are common, the former being more local than its congener. The character of the coast is unsuited to the Rock Pipit. The bird, however, occurs irregularly, chiefly in winter, and was reported many years ago to have bred near Heysham. An example of Richard's Pipit in the possession of the writer was killed at Fleetwood in 1868.

The Tree Creeper nests in suitable localities, especially in the Ribble and Hodder valleys ; and the Nuthatch formerly occurred in the wooded slopes of Wyresdale, but has not been noticed for many years.

The Goldcrest breeds in scattered localities where the spruce fir abounds ; on the approach of winter, its numbers are considerably increased by immigrants from the north. Mr. H. W. Robinson reported the nesting (for the first time in Britain) of the Firecrest near Lancaster in 1927, a full account of which will be found in 'The Ibis' for that year.

Five of the British Tits are resident. The Long-tailed, Cole and Marsh Tits, breed sparingly, mostly in the easterly portion of the district.

The Great Grey Shrike has been shot at Ribbleson and the Woodchat (according to Mitchell) at Lancaster. The Red-backed Shrike has nested, but is now very irregular. The Waxwing is a sporadic visitor.

Eleven Warblers are included. Both Whitethroats, the Blackcap, Sedge and Garden Warblers are tolerably common. All three Leaf Warblers are present, but the Chiffchaff is rare. The Reed Warbler had bred but is very rare and local. The Grasshopper Warbler nests in suitable localities, and a specimen of the Barred Warbler was shot near Fleetwood in 1898.

Six true Thrushes are found, four of them as nesting species. Numbers of small dark thrushes, akin to the Hebridean race, pass annually on migration ; their place of origin is as yet unknown. The Ring Ousel nests on the higher ground, where it usually arrives in March. The Redstart is absent from many of its old haunts ; its visits are fewer and its numbers vary from year to year. The Black Redstart has been noted and is probably fairly regular on migration. Press reports of local Nightingales have become of late years something of an annual affair, the songsters invariably turning out to be night-singing Song Thrush or Sedge Warbler. The only record for the district which ornithologists have deemed worthy of attention is that of the late Robert Standen, who stated ('Field Naturalist,' 1882) that in June, 1871, he twice saw the bird at Whittingham, near Preston, and that it sang for nearly a fortnight, when it was driven away by attempts to capture it. The Nightingale, however, is excluded from the body of Mitchell's work, though that fact does not necessarily condemn the record. The Stonechat nests in the vicinity of the coast, and the Wheatear is found breeding in similar haunts as well as on the moorland slopes. The Whinchat is less common and more local. The Greenland Wheatear, like the White Wagtail, is a regular bird of double passage along the west coast.

The Dipper haunts the streams throughout the hill country and its borderland.

The Spotted Flycatcher is common and generally distributed ; the Pied Flycatcher has bred but is generally a rare and irregular visitor.



The Swallow usually arrives about the middle of April (there is a record of one near Pilling on the 5th March, 1918), and the Martin often a week later. Both species, as well as the Sand Martin, are common.

All three British Woodpeckers have bred in the area, the commonest being the Great Spotted, which has nested periodically for many years at Ribbleton and Claughton. The Green and Lesser Spotted are very limited both in numbers and distribution. The Wryneck has long ceased to be 'a common summer visitor' to the district; the last recorded specimens were caught at Heysham in 1908.

The Cuckoo is everywhere common, the bird usually reaching the Fylde during the last week of April.

A Roller was shot at Blackpool in 1868 and there are some five or six records of the Hoopoe. The Kingfisher is tolerably common throughout the district, and frequently visits the coast.

The Swift is a common summer visitor, arriving in May and departing during August. A specimen of the rare Alpine Swift was killed at Preston in 1879.

The Nightjar, one of the latest to arrive of the summer visitors, breeds on the more secluded mosses, and in the sylvan tracts of country fringing the fells.

Five Owls occur, the commonest being the Tawny, which is undoubtedly on the increase. The Short-eared Owl breeds intermittently on one of the mosses and its numbers in autumn are increased considerably by arrivals from abroad. The Little Owl, which has been steadily extending its range since its introduction, has of late years established itself in the area. Among the 13 diurnal raptorial birds noted in the district are the Marsh and Hen Harriers, the Rough-legged Buzzard, White-tailed Eagle, Goshawk, Kite, Hobby and Osprey—nowadays all mere stragglers. The commonest of the Falconidae is the Kestrel which breeds wherever there are suitable nesting sites. The Buzzard is not infrequent in the hill country and the Peregrine pays occasional visits. (An immature bird was unfortunately shot at Bleasdale in February last). The Merlin breeds on the moors and visits the lower ground in winter. Persecution has failed to banish the Sparrow Hawk.

The Cormorant, Shag and Gannet are often seen off shore.

Large numbers of Grey Geese visit the coast in winter. They usually arrive in September and leave again in March or April. Although recent years have seen a marked increase in the number of Grey-lag and White-fronted Geese, the Pink-footed Goose is still the common goose of the district. Visits of the Bean Goose are few and far between; it may, however, pass over occasionally unnoticed, for the identification of grey geese on the wing is not the easiest of ornithological problems. The Bernicle Goose puts in a casual appearance in Morecambe Bay and isolated Brents (light-breasted form) have been killed on the coast. Both Wild Swans occur, Bewick's predominating; the Mute Swan is found on many of the larger pools and ornamental waters. The Sheld-duck is plentiful and an example of the Ruddy Sheld-duck (probably an 'escape') was shot at Barnsfold reservoir, near Preston, in 1909. Twenty species of duck are known, some of the surface-feeders like the Mallard, Wigeon and Teal being especially common. The Pintail and Shoveler are also regular and

the latter has nested. Records of Gadwall and Garganey are few. Most of the diving ducks are on the list, the only resident being the Tufted. The Pochard, Scaup and Golden-eye are regular winter visitors ; the Long-tailed Duck and Eider very occasional. The only county specimen of the Harlequin Duck was shot on the Ribble in 1916 or 1917. Large flocks of Common Scoters, sometimes accompanied by a few Velvets, appear off the coast annually, the birds not infrequently arriving as early as July. A surf Scoter was shot at Lytham in 1882. All three Sawbills are found intermittently on the coast and incidentally inland.

The Spoonbill has twice appeared on the Ribble. Three examples of the Glossy Ibis have been killed, the last one near Garstang in 1917.

Among the Heronries associated with the district are two old-established colonies at Ashton Park and Cloughton Hall. Odd specimens of the Little Bittern and Night Heron have been shot. The Common Bittern is a fairly regular winter visitor, and an American Bittern in the Preston Museum was killed at Fleetwood in 1845.

There are five rails. The Water-rail and Corncrake are widely distributed in the lower portions of the country ; the former from its skulking habits and the secluded nature of its haunts is often overlooked. The Spotted Crake is not infrequently seen. A curious variety of the Moorhen with hair-like plumage was caught at Cloughton-on-Brock in 1884. The Coot is found locally on one or two sheets of water, including Marton Mere.

The only local record of the Stone Curlew refers to two which were seen at Cloughton-on-Lune in March, 1927. The Avocet has been shot on the Ribble and in Morecambe Bay, and there is a questionable record for St. Michaels-on-Wyre in 1913. The only example of a Lancashire Black-winged Stilt was shot on Freckleton marsh in December, 1928.

The Woodcock has increased as a nesting species and is comparatively common during winter, especially in the hill-side coverts. The Common Snipe is abundant ; 73 were shot in a single day at Bleasdale in August, 1930. The Jack Snipe is widely distributed as a winter visitor, usually making its appearance at the beginning of October. Some half-dozen specimens of the Great Snipe have been secured, mostly at St. Michaels-on-Wyre. Numbers of Knots, Dunlin, Sanderling, Redshank and Bar-tailed Godwits frequent the shore, many of them in large flocks. The Curlew, Sandpiper, Ruff, Greenshank, Little Stint and Black-tailed Godwit are not infrequent. Temminck's Stint has been shot at Pilling and on the Ribble. The Green Sandpiper is one of the earliest of the autumn birds to arrive, and is regular in its visits. The Wood Sandpiper appears at uncertain intervals on its migratory course in spring and autumn, sometimes in company with other waders. The sandy shores of Lancashire are unsuited to the habits of Purple Sandpiper and Turnstone, though the birds are not entirely absent. The Common Sandpiper is less frequent inland than formerly. There are six records of the Spotted Redshank, three from St. Michaels-on-Wyre.

The Curlew nests on the moors and returns to the coast in early autumn. Spring and autumn find the Whimbrel on the shore, its numbers, as with most migratory shore-birds, varying much in different seasons. The Golden



Plover, which breeds on the fells, is widely distributed in winter when it often flocks with Lapwings. The Grey Plover is regular on passage, a remnant remaining to winter on the coast. The Ringed Plover and Oystercatcher nest on the shingle patches. Large migratory flocks of the former, composed of young birds, arrive on the coast early in August. The Dotterel is a periodical visitant, though appearing in far smaller numbers than formerly. The first British specimen of the Sociable Plover (which masqueraded for some years as a Cream-coloured Courser) was shot at St. Michaels-on-Wyre in the autumn of 1860.

The Common, Herring, Lesser Black-backed, Greater Black-backed and Black-headed Gulls are mostly abundant at all times, except that during the breeding season there is a marked diminution in their numbers. The Little Gull has been reported from Rossall and Silverdale and once or twice from the Ribble estuary. The Glaucous Gull has been observed off the south Lancashire coast and should be included. The Kittiwake is seen chiefly during spring and often in the company of other gulls. An immature Sabine's Gull in the Rossall School Museum (the only county specimen) was shot at the mouth of the Wyre in November, 1911. Mr. H. W. Robinson saw a solitary Iceland Gull at Lancaster quay in the early part of 1929.

The Common, Arctic, Sandwich and Roseate Terns are passage visitors. The Sandwich is often the first to arrive, usually at the end of March, followed by the others in April, the birds returning south in September. The Little Tern nests occasionally on the shingle; and observations of late years indicate that the Black Tern is a fairly regular passage migrant. An example of the rare Gull-billed Tern was shot at Blackpool in 1832.

Of the four British Skuas, all of which have been recorded, the Arctic is most frequent in its visits.

All five Auks and four of the Petrels are included. The Razorbill and Guillemot are common at sea, especially during winter, and oil-clogged birds are all-too-frequently met with on the tide line. A Black Guillemot was taken alive near Carnforth in 1914. Storm-driven Little Auks, Puffins, Storm and Leach's Petrels and the Fulmar are occasionally picked up exhausted both on shore and inland. The Manx Shearwater appears on passage.

Three Divers and five Grebes occur, the Dabchick as a nesting species.

There are three Doves (four if Mitchell's record of the Rock Dove is accepted). The Turtle Dove has somewhat increased its visits of late years. Pallas's Sand Grouse visited St. Michaels-on-Wyre during the 1888 'irruption'; some of the birds which fell to the gun on that occasion may be seen in the village museum.

Of the game birds the Pheasant and Partridge are common. Now and again a Red-legged Partridge appears in the district due to introduction. The Quail which was common on the newly-reclaimed mosslands sixty years ago is now a very irregular visitor. A few Black Grouse (nearly all males), the remnant of batch imported from Norway by the late Lord Sefton, exist at Abbeystead. The Red Grouse formerly bred on the mosses, but is now confined to the moorlands, where it is abundant.



## REPTILES AND AMPHIBIANS.

These number 11. A Loggerhead Turtle was caught in the Lune in October, 1927.

The Slow-Worm has occurred at Carnforth, Silverdale, Garstang, St. Michaels-on-Wyre and (this year) at Salwick. The Common Lizard is numerous and widely distributed among the sand-dunes and hedgerows. Records of the Ring Snake and Viper are few. The former has occurred at Garstang, Longridge and Preston, and Mr. H. W. Robinson reports it as not uncommon in the neighbourhood of Silverdale. The Viper has been seen at Cockerham, but is more frequent on the mosses further north.

All three British Newts are found. The Palmated Newt has been reported from Garstang, and may exist elsewhere locally as it is not always distinguished from the Smooth Newt. The Natterjack Toad (still common on the Formby dunes) is a rarity in the Blackpool district. It is found at Cockerham, however, and there is an old record for Mytton on the county border.

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## XX.

## THE LAKE DISTRICT

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I. INTRODUCTION.

SHORT geological and biological notices of the Lake District are included in this survey, because the district will be visited by many members during the Blackpool Meeting, and also because it is unlikely to find a place in any other survey in this series.

The district is unique in England in respect both of its physical characters and of the widespread esteem which its manifold natural beauties inspire. Let those be threatened, by whatever form of economic development—whether inappropriate building, road-widening, mineral working, over-orderly afforestation, or the expansion of lakes by damming for the water supply of distant towns, as at Thirlmere and Haweswater—and at once powerful expressions of public opinion are evoked in defence of the district. That defence has not yet been fully assured by means of adequate public control, but there has been definite movement towards this end, and very many people would gladly see the district ultimately conserved as a national park.

As arguments in favour of its conservation, its scientific interests are no less cogent than its aesthetic attraction. This attraction may be said to be founded upon the strong individuality of the district, and upon the extreme variety of scenery, from the severest to the gentlest beauty, which it presents within its small area. For the area within which the lakes themselves are found is embraced by a circle of only 15 miles' radius, the centre of which is a little west of Dunmail Raise, the summit of the road (782 feet) between Ambleside and Keswick.

The 'dome-like uplift of the district during Tertiary time' which 'gave rise to the radial drainage that persists to the present day,' as indicated at the close of the following section on the geology of the district, is no longer apparent on the ground, for the middle of the dome has been broken down by erosion: nor does any eminence afford sight of the radial arrangement of the main valleys, though this is evident on a map. The heads of those valleys, however, are not centralized: instead, there is a well-marked water-parting between northward and southward drainage, and on this divide Dunmail Raise, centrally placed, is the lowest point. Westward of this pass the divide runs along the heights, north of Langdale, and thence to Hanging Knotts and Great End, and to Great Gable and Pillar above Wastdale: eastward it leads by Fairfield and the Kirkstone Pass to Nan Bield, and so across the lower fells beyond. The highest points on this divide are in the west, and the highest in the whole district, Scafell Pike (3,210 feet), is near but not actually on the divide in this direction.

A broad scenic distinction, involving a threefold division, is very clearly seen between the sedimentary rocks, principally in the north and south, and the volcanic and igneous rocks, principally in the centre, as detailed in the following section.

It is with the volcanic rocks that the roughest and grandest scenery is associated; they vary in texture and hardness, and have weathered into crags, ravines and precipices contrasting strongly with the smooth outlines of the sedimentary rocks. In illustration, the easy slopes of Skiddaw may be compared with the severe, broken lines of the Scafell-Gable group of heights: Helvellyn and the noble head of Ullswater with the tranquil foot of that lake: the rugged head of Langdale with the gentle scenery around Windermere, upon which the dale debouches.

## II. GEOLOGY.

BY

T. EASTWOOD, A.R.C.S., F.G.S.

THE Lake District, with its charming and varied scenery, is within comparatively easy reach of Blackpool in these days of rapid transport. Its geology is no less interesting than its topography, but the following account can be regarded only as an introduction to this subject, and the reader is referred to the various publications of the Geological Survey, and to Marr's 'Geology of the Lake District' for further information.



## ORDOVICIAN.

The *Skiddaw Slates* are the oldest rocks in the district, and are comprised of shales, mudstones, siltstones, sandstones and grits. Owing to folding and faulting the true sequence is unknown, but the bulk of the arenaceous material—variously classed as Skiddaw Grits, Watch Hill Grit, and Loweswater Flags—is now believed to occupy a low position, argillaceous material forming the rest of the sequence with the exception of the Latterbarrow Sandstone of West Cumberland, which is there the highest member of the series. The most important fossils are graptolites, and on these Dr. Elles has divided the series into the following zones :—

- |                                   |                                  |
|-----------------------------------|----------------------------------|
| (1) <i>Bryograptus kjerulfi</i>   | (4) <i>Didymograptus hirundo</i> |
| (2) <i>Dichograptus</i>           | (5) <i>Didymograptus bifidus</i> |
| (3) <i>Didymograptus extensus</i> |                                  |

The *Borrowdale Volcanic Series*, some 10,000 feet in thickness, and made up of lavas, tuffs and agglomerates, succeeds the Skiddaw Slates, the junction in some places being a passage, in others an unconformity, but in many cases it is obscured by faulting. The lavas are mainly andesites, but rhyolites occur, though it may be noted that some of the rocks classed as rhyolites are really intrusive. The fragmentary rocks vary from exceedingly fine-grained tuffs to coarse agglomerates. When cleaved and not too coarse, these provide roofing slates—the Green Slates of Borrowdale and Coniston.

Marr and Harker, and Green, have published general sequences considered to be applicable to the whole region, but detailed work by Mitchell, Hartley, and the Geological Survey, has shown that great variations occur from place to place. A main grouping into (1) lower lavas, predominantly andesitic, (2) tuffs, (3) upper lavas, mainly andesites below and rhyolites above, may be applied if it be remembered that tuffs may be associated with the lava group (as, for example, the Mottled Tuffs at the base of, and Frostwick Tuffs within, the lower group) and lavas with the tuff group (as, for instance, the Wrengill Andesite). Even this grouping fails to the west of Wastwater, where, apart from a basal tuff, fragmentary rocks are scarcely represented.

No fossils have been found in these volcanic rocks, but their general equivalence to the Llandeilo of Wales is indicated by their position between the Skiddaw Slates and the Coniston Limestone Series.

The *Coniston Limestone Series*, which represents the Caradocian rocks of other parts of England, consists chiefly of calcareous and ashy sediments rather than good limestones. The lowest or Stile End Beds (50-250 feet), with a conglomerate at the base, rest unconformably on the Borrowdale Volcanic Series. They are followed by the Stockdale Rhyolite (0-450 feet) and the Appleshwaite Beds (100-400 feet), a conglomerate at the base of the latter marking a second unconformity. Fossils are abundant, particularly brachiopods and trilobites.

The *Ashgill Series*, about 100 feet thick, conformably succeeds the Coniston Limestone Series. At or near the base is a white limestone, about 12 feet thick, often referred to as the *Staurocephalus Limestone* from its characteristic trilobite. The rest of the series consists of shales ; some of these are ashy and mark the last phase of vulcanism during the deposition of the older Palaeozoic rocks of the Lake District.



## SILURIAN.

The Silurian strata consist of slates and sandstones of which some details are given in the table below.

The Skelgill Beds, at the base, rest conformably on the Ashgill Shales, though there is a marked change in lithology near the junction. There are eleven zones in the Skelgill Beds and two in the Browgill Beds, characterised by different species of *Monograptus*, and the trilobites *Ecrinurus punctatus*, *Phacops glaber*, and *Acidaspis erinaceus*.

| THE SILURIAN STRATA. |  | Thickness<br>in feet. |
|----------------------|--|-----------------------|
| Downton Series       | Absent....   | —                     |
| Ludlow Series        | Kirkby Moor flags ; grey-green flags with some gritty bands : much mica : some soft calcareous bands rich in brachiopods and starfish ....   | 1,500                 |
|                      | Bannisdale Slates ; leaden-grey sandy mudstones with thin bands of greenish sandstone and occasional grits : much jointed and cleaved : fossils few but include <i>Monograptus leintwardinensis</i> ....                           | 5,000 (?)             |
|                      | Coniston Grits ; fairly coarse grits with a band of flaggy mudstone ('sheer-bate flags') near middle : few fossils ....  | 4,000                 |
|                      | Upper Coniston Flags or Coldwell Beds : olive-weathering, grey flags with some grit : graptolites of <i>M.colonus</i> type : coarse grit at base with <i>Cardiola interrupta</i> and <i>Phacops obtusicaudatus</i> ....            | 1,500                 |
| Wenlock Series       | Lower Coniston or Brathay Flags ; blue-grey laminated mudstone with gritty partings : have been used for roofing tiles and flagstones : fossils not abundant but include <i>M.priodon</i> and <i>Cyrtograptus murchisoni</i> ....  | 1,000                 |
| Llandovery Series    | Stockdale Shales ; Browgill Beds, 200 feet greenish shales with dark graptolitic shales and some greenish grit : <i>Cyrtograptus</i> appears. Skelgill Beds ; 50 feet black graptolitic shales with thin, pale bands of shale .... | 250                   |

## OLD RED SANDSTONE.

Deposition appears to have ceased for a while in the Lake District after the laying down of the Kirkby Moor Flags. Earth-movements on a large scale took place, and the rocks were folded, uplifted and denuded, and were invaded by large masses of igneous material. The major anticline, recognisable amidst innumerable folds, runs east-north-east through Skiddaw and is responsible for the present distribution of the main outcrops of the Borrowdale Volcanic Series.

*Igneous Rocks.*—The Shap Granite, with its large pink crystals of orthoclase, is well known architecturally. The intrusion has taken place near the junction of the Coniston Limestone and the Borrowdale Volcanic Series, and since associated dykes penetrate strata up to and including the Ludlow, and pebbles of the granite are found in the basal conglomerate of the Carboniferous, the age is closely defined.

The chief interest in the Skiddaw Granite lies in the large aureole of Skiddaw Slates converted into rocks ranging from chialstolite slates to andalusite-cordierite-biotite hornfelses, and the greisenisation in Grainsgill accompanied by the development of quartz veins with tungsten.

The Carrock Complex consists of a series of gabbros ranging from ilmenite-rich to quartz-bearing, a hybrid diabase, a basified and a normal granophyre, and a felsite. The order of intrusion is one of decreasing basicity and the complex itself appears to be somewhat older than the Skiddaw Granite.

Lack of space precludes more than a passing mention of the microgranite of Threlkeld and the diorite of Embleton, though they are famous roadstones, and of the Armboth Dyke and the minette of Sale Fell, but attention may be drawn to the Ennerdale Granophyre and Eskdale Granite. Both are stock-like masses occurring near the junction of the Skiddaw Slates and the Borrowdale Volcanic Series with portions of the original roof preserved: both show some variations in type pointing to more than one intrusive phase, though it is more marked in the case of the Eskdale Granite. Here the northern portion is a pink perthitic granite with much quartz and muscovite, but little biotite, whereas the southern portion has much biotite and many zenoliths, and has obviously been basified.

#### CARBONIFEROUS.

*The Conglomerates* at the base of the Carboniferous have been claimed to be of Old Red Sandstone age; they possibly represent rock waste produced at this period but deposited in the early Carboniferous sea. The most important outcrops lie on the north side of the Lake District, but there are patches near Kendal and Ulverston, and a conglomerate has been proved in mining near Millom.

*The Cockermouth Lavas*, a series of olivine basalts, succeed the conglomerates in places and are the only known representatives in the region of Carboniferous igneous activity.

*The Limestone Measures* of the Lower Carboniferous show considerable variation. In West Cumberland there is about 700 feet almost entirely of limestone ranging in age from  $S_2$  to  $D_2$ , followed by a variable thickness of shales and sandstones with thin limestones, of  $D_3$  age. In a north-easterly direction this thick limestone develops a Yoredale facies and splits into several bands separated by shales and sandstones. South-east and south of the Lake District Garwood has shown that sedimentation began at an earlier date than to the north and west, and the thick dolomites and limestones there range from  $Z$  to  $D_1$ , and are followed by  $D_{2-3}$  beds of Yoredale facies.

The limestones of West Cumberland and Furness are famous for their metasomatic replacement by haematite, the iron of which was probably derived from the associated Permo-Triassic rocks.



*The Millstone Grit Series* is but feebly developed around the Lake District, and the only rocks that can with confidence be referred to this series are the shales and sandstones of the zone of *Gastrioceras cumbriense*. Zones R and H appear to be absent, though E may be represented by the upper part of the limestone measures.

*The Coal Measures* succeed the Millstone Grit conformably, but with these rocks we are not here concerned. Earth-movements, begun during the time of the Coal Measures, resulted in upheaval before the onset of the Permian.

### NEW RED SANDSTONE AND LATER ROCKS.

Rocks of Permo-Triassic age bordering the Lakeland present several interesting features pointing to unsettled conditions during the earlier part of this period. Beginning with a breccia known as the Lower Brockram, these rocks in Edenside pass upwards by way of the Penrith Sandstone, with its Upper Brockram, into the Hilton Plant Beds, Magnesian Limestone, St. Bees Shales, St. Bees and Kirkclinton Sandstones, which are succeeded by the Stanwix Shales. The Penrith Sandstone dies out to west and south, and Brockram is absent in many places, but in parts of West Cumberland replaces Magnesian Limestone and St. Bees Shales. Magnesian Limestone is again present in Furness. Gypsum deposits occur in the St. Bees Shales of Cumberland and salt in the representatives of the Stanwix Shales in Walney Island. The last-named shales are the youngest solid rocks intimately associated with Lakeland. Others, of which there is a remnant of the Lias near Carlisle, were probably deposited but later removed by the denudation which followed the dome-like uplift of the district during Tertiary times. This uplift gave rise to the radial drainage that persists to the present day and accounts for the ring-like distribution of the Carboniferous and New Red Sandstone around a core of older rocks.

Space precludes giving an account of the Glacial deposits, though erratics from the Lake District are common in the boulder clay of Blackpool

## XXI.

# THE BOTANY OF THE LAKE DISTRICT

BY

W. H. PEARSALL, D.Sc.

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TOPOGRAPHICALLY the Lake District may be held to include all the region north of Morecambe Bay, west of the London, Midland and Scottish main line, and south of a line drawn from Penrith to Maryport. Botanically, however, this region contains examples of almost every typical British plant community and it is much too varied to deal with in a limited space. It is better, therefore, to consider merely the main botanical features of the central mass of slaty rocks, since this includes all the characteristic Lakeland valleys.



To the casual visitor, the vegetation of this region falls obviously into two parts, the grasslands of the hills and the woodlands in the dales. The natural dividing line between these regions was originally in the neighbourhood of 2,000 feet. It is probably now not more than 1,700 feet in the centre of the district, as shown by the relic high level oak woods in Keskadale and elsewhere. On the exposed western margin of the hills, it may have been as low as 800 feet under natural conditions, and in some places it appears now to be only 500 to 600 feet. Owing to the naturally steep slopes, the regions above these limits were probably always natural grasslands, and extensive moorlands like those of the Pennines are uncommon.

The climax plant community at lower levels is undoubtedly woodland dominated by oak (*Quercus sessilis*). Although here, as elsewhere, the woods are much modified by planting, fragments remain in the more remote dales which appear to be in a primitive condition, as judged by their histories and by the absence of any signs of tree felling. All the best examples agree in possessing among the trees an exceptionally high proportion of oak (95 to 98 per cent.). The only usual associates are *Ilex* and *Pyrus aucuparia*. These primitive woods are generally on shallow soils.

In most cases, a varied assortment of trees is associated with evidence of disturbance of the climax forest by animals or man, or else with the probability that the mixed woodland represents a developmental type. In the latter case, the wood is colonising scree slopes, gravel deltas or lake shore spits, and disused quarry wastes. The early stages of such woodlands normally include *Betula pubescens* and sallows. Ash (usually attended by *Pyrus aucuparia*) comes in at an early stage, and is the characteristic feature of these developing woodlands. The soils are always comparatively unleached and only slightly acid. A parallel feature of Lake District oak woods, which is related to similar factors, is the presence of ash 'streaks' following the broken tracks of intermittent torrents. Ash also occurs in the damper parts of the oak woods.

It is of interest to consider certain special cases. In several places ash-birch woods are found (e.g., west of Ennerdale), and the Naddle Forest, by Hawes Water, is an extensive oak-ash-birch wood. All of these woods are of an open character; they show evidence of grazing and are developed from old scree slopes. It is probable, then, that animal and human interference have prevented the development or the maintenance of the climax oak woods, and the woodlands have, therefore, tended to remain in an earlier developmental stage.

The woodlands in the south-east of the Lake District, round Windermere, are typical of the woods on lower slopes and deeper soils. This area is of particular interest as the most heavily wooded part of Britain, and it owes this distinction to the persistence of local industries depending upon the woodlands. Charcoal burning is still carried on in order to supply the iron works at Backbarrow, and the abundance of 'bloomery' sites as well as historical evidence show that this industry has persisted from the earliest historical times.

With the introduction of modern methods of iron smelting at Barrow, the woodland products were diverted for a time to the making of gunpowder, cotton 'bobbins' and baskets, although these industries are now extinct. To meet these local needs, the woods were generally maintained as some form of coppice, and although, in the last 50 years, many of them have been allowed

to grow up, they all contain a considerable abundance of small timber, mainly hazel and birch, as well as a considerable variety of trees, many of which have been introduced. Of the native trees, *Prunus Avium* is possibly the most constantly and widely distributed species; ash, elm and *Prunus padus* are frequent in the damper places, while yew, *Taxus baccata*, may form dense communities on the more broken rocky knolls and outcrops.

The ground flora of these woods is less uniform than that of the typical dry oak wood, and both mosses and ferns are more frequent. The community of *Scilla*, *Holcus mollis* and *Pteridium* exists in various forms where the soil exceeds nine inches in depth. More commonly, bluebells and *Holcus* occur with an abundance of *Mnium hornum*, some *Anemone* and mosses such as *Hylocomium triquetrum*. On damper slopes, particularly those with a northerly aspect, this community changes to one in which *Mnium hornum* is associated mainly with *Oxalis acetosella*, and ferns, *Dryopteris aristata* and *D. Filix-mas*. At the bottom of slopes, dog's mercury and garlic (*Allium ursinum*) are likely to be found, their commonest associate being the moss, *Eurhynchium praelongum*.

The characteristic feature of these woods is, however, the frequency of rocky knolls, mainly covered by such mosses as *Dicranum majus*, *Hypnum cupressiforme*, *Plagiothecium undulatum* and *Leucobryum glaucum*. The higher plants are usually represented by bilberry (*Vaccinium Myrtillus*), *Deschampsia flexuosa* and *Luzula pilosa*. *Melampyrum pratense* and its variety *hians* are often found on or near these knolls. The soil is extremely acid, usually below pH 5. Another common and wide-spread ground flora is dominated more or less completely by grasses to the ultimate exclusion of other herbaceous plants. The grasses usually include *Agrostis* spp., *Holcus* spp., *Festuca ovina* and *Anthoxanthum odoratum*. In various modifications, this grassy type of ground flora may occur over an extremely wide range of soil types, and there is no doubt that it is developed mainly where grazing by animals is or has been possible, although it is possible that the shallow soils may also be a contributing factor in its development.

The importance of the effects of grazing animals, here mainly sheep, rabbits and to a less extent deer, can hardly be over-estimated in the Lake District. The grassy and grazed type of woodland just described merges naturally into the grasslands of the hill slopes. The absence of tree seedlings in grassy woodlands indicates that such woodlands normally fail to regenerate and must give way to grassland. The typical Lake District grasslands are, in fact, biotic plant communities whose extension and maintenance depends on grazing. The extreme importance of the pressure exerted by animals is not easily realised, but it is at once apparent if one stands above one of the steeper slopes, when the light is shining on it obliquely at an angle nearly that of the slope. Then the slope is seen to be terraced by thousands of horizontal sheep tracks, giving a most striking demonstration of the severity of animal pressure.

It is probable that the grasslands have always existed above the tree limit, and it seems equally probable that their downward extension has been going on since the earliest times. The prehistoric remains in this district are confined to the hill tops, and, moreover, they show a quite striking correlation with what are to-day the best grazing grounds. It would seem logical to suppose that the early inhabitants dwelt and pastured their flocks above the forest limits, and



there would hence, for example, be justification for such features as the Roman road along the High Street range. The clearing of the valleys seems to have been left to the Scandinavian invaders of comparatively recent times.

As the grasslands are of biotic origin, they show marked tolerance for a variety of soil conditions, and undoubtedly their detailed composition is affected by the local grazing pressure. *Agrostis vulgaris*, *Festuca ovina* (especially var. *capillata*), *Galium saxatile* and *Hylocomium squarrosus* are the species most constantly present. *Nardus stricta* and *Juncus squarrosus* become abundant or dominant on the damper slopes, typically on glacial clay or redistributed peat. This type of grassland is especially common on the drift-covered slopes in the north-west.

In the south, the Bannisdale flags and grits often yield an undulating surface of which the knolls bear *Calluna* and *Erica cinerea*, while grasslands, usually with *Pteridium*, occupy the hollows. Juniper is abundant in this area, and on the flatter-topped hills an interesting damp *Calluna*-juniper heath may be developed, though the burning of these areas for grouse is rapidly reducing the proportion of juniper. *Calluna* moors, however, are only commonly developed on the Skiddaw slates in the north. These rocks are rather poorer in bases than the typical Borrowdale slates, and their grasslands are less extensive. *Vaccinium* 'edges' are also characteristic of the sharper ridges on these rocks, that of Cat Bells being a convenient example. Deep peats are rather local in the Lake District, and they usually show extensive signs of degeneration. They are confined to a few of the flatter hill tops, particularly round Hawes Water and on Mungrisdale Common, and to hollows above 1,500 feet. *Scirpus caespitosus*, *Eriophorum vaginatum* and *Juncus squarrosus* are usually characteristic in the vegetation. The peat-forming plant was mainly cotton-grass. Buried timber, usually birch, occurs up to 2,000 feet.

The higher hills, above 2,000 feet, are normally either grassland, crag or scree, and the summits, if not of rock detritus alone, tend to vary between a sparse grassland and *Rhacomitrium* heath. The latter is less common, and it is perhaps best developed on Grassmoor, where *R. lanuginosum* is dominant along with both *Vaccinium myrtillus* and *V. Vitis-Idaea*, *Lycopodium selago* and *L. alpinum*, *Empetrum nigrum* and the viviparous form of *Festuca ovina*. Lichens are abundant, but not fully known. *Cetraria aculeata*, *Cladonia* spp., *Cetraria islandica* and *Sphaerophora fragilis* are recorded as the most characteristic. The more typical summits (e.g., Helvellyn) are clothed with sparse sub-alpine grassland, in which the most typical new elements are a dwarf form of bilberry and *Carex rigida*. *Salix herbacea* usually occurs on this type of summit, but in the more rocky places. The real arctic-Alpine element in the Lake District flora is small, and the species are mainly of local distribution, as for example, *Lychnis alpina* on Hobcarton Crags. The most typical plants of the higher hills are *Allosorus crispus*, the parsley fern and *Alchemilla alpina*. The abundance of these species here is in great contrast with their scarcity in the Pennines. In the flushes, *Saxifraga stellaris* and *S. aizoides*, usually with *Montia fontana* and a variety of mosses, are perhaps most typical.

No account of the botany of the district would be complete without some reference to the aquatic plants. In regard to these, the particular interest of the Lake District lies in the fact that the lakes represent a series giving various



stages in the post-glacial development of aquatic vegetation. This is largely because the underlying rocks vary considerably in hardness, and as a result some of the lakes have developed more slowly than others. These more primitive lakes (e.g., Wastwater and Ennerdale) have a sparse colonising vegetation in which *Isoetes lacustris* and *Nitella opaca* are most characteristic of deep water, while *Littorella* is usually present in the shallows. Any silts are coarse and poor in bases, and the silted places are likely to support *Juncus fluitans*, *Callitriche intermedia* and, more rarely, *Potamogeton pseudofluitans*, a submerged form of *P. polygonifolus*. As lake development progresses, silting increases, and the sub-strata also become more organic in character. Submerged species of *Potamogeton* become frequent, especially *P. perfoliatus*, *P. praelongus* and *P. pusillus*. *Lobelia Dortmanna* and reeds (chiefly *Scirpus lacustris* and *Phragmites*) become more frequent on the margins.

In still later stages, when the sub-strata as a whole are organic, water-lilies, *Potamogeton natans*, *Equisetum limosum* and *Carices* extend over the margins, while submerged plants such as *Sparganium minimum*, *P. alpinus* and *P. obtusifolius* are characteristic of greater depths of water. Many of the smaller and shallower lakes have disappeared, and their position is only indicated by peat mosses (e.g., Rusland and Shoulthwaite) bearing vegetation of the 'lowland moor' type. While in some cases, the reed swamps of the lakes developed to moor through a well-defined woodland stage in which willows and birch were prominent, in other cases the woodland stage may have been less well-marked or nearly absent. The bogs at the south end of Hawes Water exemplify a transitional condition of this type. In general, the woodland development seems to be associated with a greater relative abundance of inorganic silts or with a more decided influence from telluric waters.

Taxonomically, the most interesting aquatic plants are *Najas flexilis* and *Hydrilla verticillata*, both confined to Esthwaite Water, and elsewhere very rare in the British Isles. *Potamogeton pusillus* is represented mainly by the sub-species *lacustris*, a broad-leaved form not found in other parts of England.

The sequence of stages in lake development shown in the study of higher plants is apparent also in relation to the plankton and littoral algae of the lakes. The primitive or rocky lakes have a rather sparse flora in which desmids and green algae are predominant. A further stage in development is marked by the appearance of abundant diatoms, especially *Asterionella* and *Tabellaria fenestrata* in the plankton. The latest stage is shown by an abundance of blue-green algae such as *Anabaena* and *Coelosphaerium*. It is of interest to note that the last transition has actually been observed in Windermere, though there it is not entirely due to natural causes.

The great influx of visitors to the district from 1910 onwards has led to an increase in the volume of sewage effluents reaching the lake and hence to an increase in the amount of organic matter in its waters. Hence, also, blue-green algae have become a constant element in the phyto-plankton, although they were practically absent in 1907-8.

Enough has been said to indicate that the lakes offer great possibilities to students of aquatic biology. The establishment of a laboratory at Wray Castle, on Windermere, by the Fresh-water Biological Association may be regarded as an index of the scientific and practical interest these problems arouse.

## XXII.

## MAMMALS OF THE LAKE DISTRICT

BY

H. J. MOON, M.R.C.P.

IN view of the comparatively few mammals known to the English Lake District, a list of recorded species with appended notes is the most satisfactory method of dealing with the subject.

Bats (*Chiroptera*). No comprehensive survey of local bats has yet been made, but below is a list of authentic records :—

Whiskered bat (*Myotis mystacinus*). One specimen found near Windermere in 1922.

Daubenton's bat (*Myotis daubentonii*). Occurs sparingly throughout the district : often mistaken for the common bat.

Common bat (*Vespertilio pipistrellus*). Common everywhere.

Serotine (*Vespertilio serotinus*). Several records.

Great bat (*Nyctalus noctula*). Not uncommon.

Long-eared bat (*Plecotus auritus*). Common everywhere.

Barbastelle (*Barbastella barbastellus*). Suspected, but its presence not definitely proved.

Fox (*Vulpes canis*). The English Lake District foxes are so numerous as to be a menace to sheep farmers and poultry keepers. Despite three packs of hounds, hunting three days a week from October to April, and killing about 150 foxes a year, there seems to be no diminution in numbers. The Lake District foxes are usually large compared with those elsewhere in England.

Badger (*Meles taxus*). Though not plentiful, they are not so scarce as is supposed, for their nocturnal habits conceal their presence.

Otter (*Lutra vulgaris*). Plentiful everywhere.

Pine marten (*Mustela martes*). Now very scarce, though 50 years ago were so plentiful as to be hunted regularly. The felling of forests, and persecution by man, are supposed to have brought the creature to the verge of extinction, but it is more probable that some natural cause, such as disease or food shortage, has obtained.

Stoat (*Mustela erminea*). Far too numerous everywhere.

Weasel (*Mustela nivalis*). Common everywhere, but less so than the stoat.

Polecat (*Mustela putorius*). Once not uncommon, now extinct. The last record was from Ullswater in 1922.

Red squirrel (*Sciurus vulgaris*). Distributed throughout the Lake District, but varies in numbers from year to year. Internal parasites and mange keep the numbers in check.

Grey squirrel (*Sciurus cinereus*). Up to the present this alien pest has not appeared in the district.

Dormouse (*Muscardinus avellanarius*). Has been reported, but is very scarce.

Harvest mouse (*Micromys minutus*). Not yet proved to be present.

Wood mouse (*Apodemus sylvaticus*). Almost a plague in many parts of the district.

House mouse (*Mus musculus*). An unwelcome guest everywhere.

Black rat (*Epimys rattus*). No authentic record for many years.

Brown rat (*Epimys norvegicus*). An ever-present curse.

Water vole (*Arvicola amphibius*) and field vole (*Microtus agrestis*). Common.

Bank vole (*Evotomys glareolus*). Scarce, but has been reported many times.

Rabbit (*Oryctolagus cuniculus*) and brown hare (*Lepus europæus*). Common.

Red deer (*Cervus elaphus*). A herd of about 150 range the Helvellyn area. These are the only truly wild deer in England outside the West Country, and are lineal descendants of the deer hunted by one of the Plantagenet kings when that area was a royal deer forest.

Fallow deer (*Cervus Dama*). A large herd of semi-wild fallow deer exist on Gowbarrow overlooking Ullswater. A few are supposed to lurk here and there in other areas.

Roe deer (*Capreolus capraea*). A few still remain in the well-wooded areas near Windermere, and stragglers occur in a few other quiet corners of the Lake District.

Hedgehog (*Erinaceus europæus*). Common.

Mole (*Talpa europaea*). Common.

Common shrew (*Sorex araneus*). Well-distributed and a welcome (or ought to be) friend to farmers and gardeners, for it lives almost entirely on insects, snails and other pests.

Lesser shrew (*Sorex minutus*). Very local.

Water shrew (*Neomys fodiens*). Rather local, but not as uncommon as supposed.



## XXIII.

SUMMER BIRD LIFE  
OF THE LAKE DISTRICT

BY

H. J. MOON, M.R.C.P.

FROM north to south the Lake District measures approximately 30 miles, while from east to west it measures about 25 miles. The area varies in altitude from nearly sea-level to over 3,000 feet, and comprises vale, fell and mountain, swamp, lake, forest and river, with very little arable land, but much rough pasture.

As each type of area presents its own bird population, the Lake District is one of the richest parts of England as regards variety of bird life. For convenience of description the area may be divided into dale, low fell, high fell and mountain. (Dale, 50 feet to 500 feet.)

Most of the birds common to Northern England are represented, but there are some notable exceptions, and some peculiarities in distribution.

The green woodpecker (*Picus viridis pluvius*) is unknown, its place being taken by the great spotted woodpecker (*Dryobates major anglicus*).

The lesser whitethroat (*Sylvia curruca curruca*) is extremely rare: the chiff-chaff (*Phylloscopus collybita collybita*), blackcap (*Sylvia atricapilla atricapilla*), tree sparrow (*Passer montanus montanus*), and stock-dove (*Columba oenas*) are very local, and unknown to the greater part of the area. The turtle dove (*Streptopelia turtur turtur*) does not occur. The house sparrow (*Passer domesticus domesticus*) is also very local, being a rare bird in some of the dales. The common linnet (*Carduelis cannabina cannabina*) is very local, and only found where furze bushes are plentiful.

Sand martins (*Riparia riparia riparia*) are also scarce, owing to the lack of suitable nesting areas in a volcanic area overlaid by hard glacial drift.

A special feature is the pied fly-catcher (*Muscicapa hypoleuca hypoleuca*), which nests freely throughout the eastern portion of the district. The twite (*Carduelis flavirostris flavirostris*) nests in most heathery localities, as does its mortal enemy the merlin (*Falco regulus regulus*) in the face of merciless persecution.

The crossbill (*Loxia curvirostra curvirostra*) nests regularly in at least two areas of the Lake District. The long-eared owl (*Asio otus otus*) is almost unknown in the Lake District, and the little owl (*Athene noctua noctua*) has not yet been reported. The tawny owl (*Strix aluco aluco*) is common everywhere.

The hawfinch (*Coccothraustes coccothraustes coccothraustes*) is well distributed as a breeding species, and the lesser redpoll (*Carduekis linaria cabaret*) nests freely in most parts of the district, as does the golden crested wren (*Regulus regulus anglorum*). The willow titmouse (*Parus atricapillus kleinschmidtii*) has not as yet been noted as a breeding species. The woodcock (*Scolopax rusticola*) nests in all suitable spots, and the black grouse (*Lyrurus tetric tetric*) in one area. Whinchats (*Saxicola rubetra rubetra*) are well distributed, but the stonechat (*Saxicola torquata hibernans*) is extremely scarce.

The tree pipit (*Anthus trivialis trivialis*) is plentiful in most areas, but is rarely seen above the 500 foot level, where it is replaced by the meadow pipit (*Anthus pratensis*), and the two birds rarely overlap as breeding species.

Lapwings (*Vanellus vanellus*), curlews (*Numenius arquata arquata*) and redshanks (*Tringa totanus*) all nest freely in suitable localities. Teal (*Anas crecca crecca*) are very local, and tufted duck (*Nyroca fuligula*), though local, are extending their range as breeders. The shoveller (*Spatula clypeata*) has not yet been known to nest in the Lake District.

Many colonies of black-headed gulls (*Larus ridibundus*) exist throughout the Lake District. The dunlin (*Erolia alpina alpina*) is unknown to the district as a nester.

Moor-hen (*Gallinula chloropus chloropus*) and dabchicks (*Colymbus ruficollis ruficollis*) present a peculiar distribution. In winter they are seen on nearly every lake and tarn, but in spring they desert the open waters in favour of small ponds and ditches. Most of the lakes and tarns are subject to great variations of level owing to frequent heavy rains, and therefore are unsuitable as nesting places. Coots (*Fulica atra atra*), though common in winter, are very scarce as breeders, and the great crested grebe (*Colymbus cristatus cristatus*) has only nested once or twice in the Lake District.

The common buzzard (*Buteo buteo buteo*), despite much persecution, still holds its own as a breeding species throughout the area.

Hérons (*Ardea cinerea*) nest freely throughout the district, but since several colonies have been evicted, they are tending to become solitary nesters. Grey wagtail (*Motacilla boarula boarula*) and dipper (*Cinclus cinclus britannicus*) are found near every lake, tarn and beck, and nearly every bridge in the district is used as a nesting site.

Kingfisher (*Alcedo ispida ispida*), though still very local, are becoming more frequent every year, despite the fact that their brilliant hue renders them very conspicuous to marauding sparrow hawks.

Skylarks (*Alauda arvensis arvensis*) are rarely seen in dales where high hills hide the horizon, but wherever the bird can glimpse the far distance it is present.

Magpies (*Pica pica pica*), though very common in the south of the Lake District, are very scarce north of Kirkstone Pass : usually about four pairs nest annually. Jays (*Garrulus glandarius rufitergum*) are also common south of Kirkstone Pass, but almost unknown north of it.

## LOW FELLS.

Wheatear (*Oenanthe oenanthe oenanthe*), meadow pipit (*Anthus pratensis*), jackdaw (*Coloeus monedula spermologus*), carrion crow (*Corvus corone corone*) reign supreme, though sandpipers (*Tringa hypoleuca*) have nested at 1,100 feet. Yellow wagtail (*Motacilla flava rayi*) at 800 feet, lapwing (*Vanellus vanellus*) at 1,200 feet, and dipper (*Cinclus cinclus britannicus*) at 1,000 feet, and the ring ousel (*Turdus torquatus torquatus*), though thinly distributed, nest regularly on the low fells.

The hooded crow (*Corvus cornix cornix*) is rarely seen in the Lake District, but one case of inter-breeding between it and the carrion crow (*Corvus corone corone*) has been recorded.

Strange to say, the cuckoo (*Cuculus canorus canorus*) is rather a bird of the low fells than the dales, where pipits are its chief victims.

## HIGH FELLS (1,200 feet to 2,000 feet).

The kestrel (*Falco tinnunculus tinnunculus*), common buzzard (*Buteo buteo buteo*), peregrine falcon (*Falco peregrinus peregrinus*) and raven (*Corvus corax corax*) share the high fells between them, and nearly every few square miles has its nesting pair of these birds.

In winter snow buntings (*Plectrophenax nivalis*) haunt the low fells, often in company with lesser redpolls (*Carduelis linaria cabaret*).

## MOUNTAIN (2,000 feet to 3,210 feet).

The dotterel (*Charadrius morinellus*) still nests sparingly on two Lake District mountains, and is the only bird the Lake District claims as a summer resident of the mountain tops.

## XXIV.

SCIENTISTS OF  
NORTH LANCASHIRE AND VICINITY

BY

D. N. LOWE, M.A., B.Sc.

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OF the following men who, in the course of the past 300 years, have made significant contributions to the advancement of scientific knowledge, all but a few were born in the north-west of England, in the area embracing Lancashire north of the Ribble, Cumberland and Westmorland.

The few exceptions either had close family connections with, or were long resident in the district. Though they are not strictly in the area so defined,



it has been considered convenient to include Stonyhurst College Observatory and Sedbergh in the present survey. Grateful acknowledgment is made in respect of notes on past Directors of Stonyhurst College Observatory, which were compiled by the Rev. J. P. Rowland, S.J., the present Director.

ADDISON, THOS. (1793-1860), *b.* Long Benton, near Newcastle. Came from a family long settled at Lanercost, Cumberland. Studied and lectured on diseases at Guy's Hospital. His discovery, in 1855, of what is now known as 'Addison's Disease' was considered one of the most brilliant achievements of the nineteenth century. Died at Brighton. Buried in Lanercost Abbey.

ARKWRIGHT, Sir RICHARD (1732-92), *b.* Preston, of humble parents. Apprenticed to a barber, he set up business in Bolton in 1750, and with the gradual disuse of wigs turned to invention. In 1769 invented and erected near Hockley the first spinning mill. In 1775 patented a series of inventions for performing on one machine the whole process of yarn manufacture. From the building of his numerous mills in Lancashire and Derbyshire we may properly date the factory system. Died at Cromford.

BARROW, Sir JOHN (1764-1848), *b.* Dragley Beck, near Ulverston. Started work in a Liverpool iron foundry and rose to be a partner. Extensive travel earned him important connections, and after holding various political offices he became Secretary to the Admiralty. Explorer and traveller, he wrote extensively. Founded the Royal Geographical Society in 1830. Died in Camden Town.

BRACKEN, Dr. H. (1679-1764), *b.* Lancaster. Studied medicine and surgery in London, Paris and Leyden, and practised in Lancaster. Was widely known for his prowess in surgery, and wrote several books on farriery which brought him into the front rank of veterinary writers. Died Lancaster.

BROUGHAM, H. P., F.R.S., Baron Brougham and Vaux (1778-1868), *b.* Edinburgh. He was descended from a Westmorland family, and kept an estate in that county. Showed early promise in scientific studies, but took up law, and rose to be Lord Chancellor. Formed a society for the diffusion of useful knowledge, was Rector of Glasgow and Chancellor of Edinburgh Universities, and founded London University. When he withdrew from public life he resumed scientific studies, and published papers on light. Died abroad.

BROWNRIGG, Dr. WM., F.R.S. (1711-1800), *b.* High Close Hall, Cumberland. Studied medicine London and Leyden, and practised at Whitehaven. Elected F.R.S. (1741) for researches in fire-damp. Made valuable enquiries into the nature of mineral waters, and was probably the first to realise the acid nature of carbon dioxide. In many particulars his researches were parallel to those of Priestley, Black and Cavendish. First to give an account of platinum. Died at Ormathwaite, near Keswick.

CAVENDISH, Sir WM., K.G., P.C., Seventh Duke of Devonshire (1808-1891), *b.* London. On inheriting large estates in this country and in Ireland gave up a career in politics to administer scientific and industrial concerns. Assisted in establishing iron-mining and steel-producing industries in Barrow. In turn Chancellor of Cambridge, London and Manchester Universities. Presented the Cavendish Laboratory to Cambridge. An enlightened land-

owner and breeder of cattle, he fostered agriculture and helped to found the Royal Agricultural Society (1839). Died Holker Hall, near Grange, Lancs.

CHAMBERS, EPHRAIM, F.R.S. (died 1740), *b.* probably about 1680 at Kendal. Apprenticed in London to a globe and map maker. In 1728 published a 'Cyclopaedia or Universal Dictionary of Arts and Sciences,' for which he was elected F.R.S. Visited France and translated many French scientific works. Died in London; buried in Westminster Abbey.

COLLINSON, PETER, F.R.S. (1694-1768), *b.* near Windermere. Well-known botanist, zoologist and antiquary. Elected F.R.S. in 1728. The son of a merchant, he extended his father's business to America, and encouraged intercourse between scientists on both sides of the Atlantic. Kept Benjamin Franklin abreast with advance in electrical experiments in Europe, and advised several of the American States to grow flax, hemp and vines. Had a considerable reputation as a botanist, and came near to being elected curator of the Botanical Department of the British Museum.

CORTIE, Father ALOYSIUS LAWRENCE, S.J. (1859-1925), *b.* London. Educated at Stonyhurst College. Entered the Society of Jesus in 1878. Professor of Physical Science at the College for many years, and Director of the Observatory from 1919. F.R.A.S., 1891, and served on the Council. Director of the Solar Section of the British Astronomical Association, 1900-1910. He was in charge of the expedition to observe the total solar eclipse at Vinaroz, Spain, in 1905, and also of the Government expedition to the Tonga Islands in 1911 for the same purpose. He also went to Hernösand, Sweden, for the total eclipse of 1914. In 1922 the University of Padua conferred on him the degree of D.Sc. (*Hon. causa*). Besides being a well-known lecturer on astronomical subjects, he was the author of numerous papers on solar and stellar physics. Died at Stonyhurst.

DALTON, JOHN, F.R.S. (1766-1844), *b.* Eaglesfield, near Cockermouth. Son of a Quaker weaver, he was self-taught. Teacher in Kendal for 12 years. Professor of Mathematics, New College, Manchester, 1793. Discovered the law of chemical combination, and tabulated atomic weight of various elements. Published *A New System of Chemical Philosophy*. Regular attender at British Association meetings; was Vice-President of Section B (Chemistry) in 1835 and 1836. Died Manchester.

DAWSON, JOHN (1734-1820), *b.* Garsdale, near Sedbergh. Taught himself mathematics while tending sheep, and soon knew enough to become an itinerant master. Later apprenticed to a surgeon in Manchester. Took a medical degree at Edinburgh and set up practice in Sedbergh. Kept abreast with mathematics and gained such a reputation as a teacher that Cambridge men flocked to him. Between 1781 and 1794 he counted eight senior wranglers among his pupils.

DODSWORTH, ROGER (1585-1654), *b.* Newton Grange. Went to school at Warton, and became an antiquary at an early age. Lived at Hutton Grange from 1611-1654. Published nothing during his life-time, but designed three works, an English Baronage, a History of Yorkshire and Monasticon Anglicanum, the notes for which represented extensive antiquarian researches. Many of his MSS. are preserved in the Bodleian. Died at Hutton Grange; buried at Rufford.



FERGUSON, R. S. (1837-1900), *b.* Carlisle of a family who founded the cotton industry there in 1700. Educated Carlisle Grammar School and St. John's, Cambridge. Called to the bar in 1862. Retiring through ill-health in 1872, he devoted himself to the study of local antiquities, having previously founded the Cumberland and Westmorland Archaeological Society (1866). Under his guidance nearly the whole of Cumberland and Westmorland were explored and records made of castles, churches, houses, manuscripts and old customs. His own period was the Roman occupation of Cumberland. Published and edited numerous antiquarian works. Died at Carlisle.

FLETCHER, ABRAHAM (1714-1793), *b.* Little Broughton, Bridekirk, Cumberland. Son of a tobacco-pipe maker, he was apprenticed to the trade. Taught himself mathematics, and acquired a considerable reputation as a teacher. Increased his income by sale of herbal decoctions, and was known by many as Dr. Fletcher. Also studied judicial astrology. Published two books, *The Universal Measurer* (1753) and *The Universal Measurer and Mechanic* (1762).

FOTHERGILL, ANTHONY, F.R.S. (1732-1813), *b.* Sedbergh. Studied medicine at Edinburgh and practised in Northampton, London and Bath. Elected F.R.S., 1778. A skilful doctor, he also possessed scientific attainments, especially in chemistry, which he applied to analysis of mineral waters. Best known for researches and papers on restoring persons apparently dead from drowning. Died in London.

FRANKLAND, Sir EDWARD, K.C.B., F.R.S. (1825-1899), *b.* Churchtown, near Lancaster. Chemist apprentice at Lancaster, then studied in London and at Marburg. Professor of Chemistry at Putney College (1850) and at Owen's College, Manchester (1851). F.R.S., 1853. Royal medallist 1857. He lectured in Chemistry at St. Bartholomew's Hospital, London, and was Professor of Chemistry at the Royal Institution (1863-8). Served on royal commission on river pollution from 1868. Made notable contributions to organic chemistry. His works include *Experimental Researches in Pure, Applied, and Physical Chemistry*.

GARNETT, THOS., M.D. (1766-1802), *b.* Casterton. Son of a landed proprietor. Studied medicine in Edinburgh and London and practised in Bradford and Harrogate. Made the first scientific analysis of the Harrogate waters. After a tour of lectures in natural philosophy he became Professor of Physics at Anderson's Institute, Glasgow, and later Professor of Physics and Chemistry at the Royal Institution (1799-1801). Died London.

GASKIN, Rev. THOS., F.R.S. (1810-1887), *b.* Penrith. Educated Sedbergh and St. John's College, Cambridge. Second wrangler, second Smith's prizeman, 1831. Fellow and Tutor, Jesus College. F.R.S., 1839. Moved to Cheltenham, 1855, and spent the rest of his life there, teaching private pupils. Wrote many mathematical papers. Died Cheltenham.

GOUGH, JOHN (1757-1825), *b.* Kendal. Eldest son of a Quaker shearmender. Robbed of his sight when a child, he trained his sense of touch and became an accomplished botanist. He quickly mastered mathematics, which he taught to John Dalton (*q.v.*). Wrote some 50 essays on a wide variety of scientific topics with a skill and accuracy amazing in one who was so long blind. Died at Kendal.



HIND, JOHN (1796-1866), *b.* Cumberland. Entered St. John's College, Cambridge, 1813, and was second wrangler and second Smith's prizeman in 1818. Lectured in mathematics in Sidney Sussex College, and published several works on the differential calculus and other mathematical subjects.

HODGSON, Rev. JOHN (1779-1845), *b.* Swindale, Westmorland. Educated at Bampton Grammar School, became a schoolmaster first at Ullswater, then at Penrith, and finally in Durham, where he remained till he took orders (1804). Wrote and published many works on antiquarian subjects. Helped to found the Society of Antiquaries in Newcastle. A colliery explosion in his parish at Felling (Newcastle, 1813) gave him an interest in the dangers of coal mining, and Sir Humphry Davy acknowledged Hodgson's assistance in enabling him to complete his invention of the safety lamp (1817).

HUCK, Dr. RICHARD, F.R.S. (1720-1785), *b.* Westmorland. Apprenticed to an apothecary at Penrith. Studied medicine at St. Thomas's Hospital, London, and at Aberdeen University. In 1750 became a regimental doctor and eventually became Physician to the Army. Physician to Middlesex Hospital, 1766; St. Thomas's Hospital, 1769. Elected F.R.S., 1768. Died London.

HUDDART, Capt. JOSEPH, F.R.S. (1741-1816), *b.* Allonby, Cumberland. The son of a shoemaker and farmer, he had a simple education. Sent to sea, where he studied navigation and surveying. In 1771 he entered the East India Company, and, as commander of one of their ships, made four voyages to the East. Surveyed the coasts and ports that he visited and constructed charts of Sumatra and the coast of India from Bombay to the mouth of the Godavery. On retiring spent three years surveying among the Hebrides. Elected F.R.S., 1791. Died in London and was buried in St. Martin-in-the-Fields.

HUDSON, WM., F.R.S. (1730-1793), *b.* Kendal. Son of an inn-keeper. Educated at Kendal Grammar School. Best known as a botanist, he also studied molluscs and insects. From 1757 to 1758 he was sub-librarian of the British Museum, where he studied intensively in the Sloane herbarium. Elected F.R.S. in 1761, the year following the publication of his 'Flora Britannica,' which was said by contemporary authorities to mark the establishment of Linnaean principles of botany in England. Died in London.

LAWSON, THOS. (1630-1691), *b.* (?). Educated at Cambridge for the Church, he was presented with a living at Rampside, Lancs., but gave up preaching 'for hire,' and joined the Quakers (1653). Settling at Strickland, Westmorland, in 1658, he took in private pupils, and devoted much of his spare time to botany. Said to be the most noted herbalist of his day. Described by Ray as a 'diligent, industrious and skilful botanist.'

LEAKE, JOHN, M.D. (1729-1792), *b.* Ainstable, Cumberland. Son of a clergyman. Studied surgery, specialising in midwifery. After studying in Lisbon and Rheims became a licentiate of the College of Physicians, and settled down to lecture and practise in London. Wrote several books on the diseases peculiar to women, and an introduction to the theory and practice of midwifery. Died London; buried Westminster Abbey.

LONSDALE, HENRY, M.D. (1816-1876), *b.* Carlisle. Studied medicine in Edinburgh and Paris. While in practice at Raughton Head, Cumberland,

helped to found Inglewood Agricultural Society, a monthly club and the first of its kind in the county (1838). Also gave popular lectures in science. Held several important medical posts in Edinburgh, and in 1841 introduced for the first time in Edinburgh the use of cod-liver oil. After his marriage in 1851 he spent most of his time in archaeological researches, chiefly in S. Europe, and in collecting material for and writing biographies.

LOWRY, WILSON, F.R.S. (1762-1824), *b.* Whitehaven. Son of a portrait painter who led a wandering life, he went to London when he was 18. Becoming an engraver of note, he invented several ingenious instruments, e.g., a ruling machine, and others, for striking elliptic curves, and for making perspective drawings. He was the first to use diamond points for ruling. Spent 20 years engraving plates for Rees' Encyclopaedia. Many of his plates of scientific instruments are of unequalled beauty. Elected F.R.S., 1812.

MORTON, Dr. CHAS., F.R.S. (1716-1799), *b.* Westmorland. Studied medicine at Leyden, and practised in Kendal and London. On establishment of British Museum (1756) he was appointed sub-librarian, and became principal librarian in 1776. Elected F.R.S. in 1752, he was Secretary to the Royal Society from 1760-1774.

NICHOLSON, Prof. H. A., F.R.S. (1844-1899), *b.* Penrith. Educated Appleby Grammar School and Göttingen University; and Edinburgh University. In an active life-time he held the following chairs:—Natural History, Toronto (1871-74); Physical Science, Durham (1874-75); Natural History, St. Andrews (1875-82); Natural History and Geology, Aberdeen (1882-99). He had a bias towards the palaeontological side of zoology, and made a special study of graptolites. Worked out the succession of palaeozoic rocks of the Lake District. Wrote many text-books, including a *Manual of Zoology* and a *Manual of Palaeontology*. Died Aberdeen.

NICOLSON, Rev. WM., F.R.S. (1655-1727), *b.* Plumbland, Cumberland. Son of the Rector there, he studied for the Church at Oxford and on the continent and, after occupying three charges in Cumberland, became Bishop of Carlisle and afterwards Bishop of Derry, in Ireland. Made a hobby of collecting documents and contributed much to antiquarian works. His own publications included a *Historical Library* for England, Scotland and Ireland (three separate volumes) and *Border Laws*.

OWEN, Sir RICHARD, C.B., F.R.S. (1804-1892), *b.* Lancaster. Son of a West India merchant. Educated at Lancaster, Edinburgh University, St. Bartholomew's and Paris, where he studied under Cuvier. Made his name as an anatomist in 1832 with *Memoir on the Pearly Nautilus*. F.R.S., 1842. First Hunterian Professor of Anatomy and Physiology, and first President of the Microscopical Society. As Superintendent of the British Museum natural history collections (1856-83) obtained their removal to S. Kensington (1881). President of the British Association in 1858 (Leeds). Wrote widely on all manner of subjects dealing with natural history. One of the most acrimonious controversialists of his day. Died at Sheen Lodge.

PATTINSON, H. L., F.R.S. (1796-1858), *b.* Alston, Cumberland. Son of a Quaker retail trader, he was educated privately. Specialising in chemistry and electricity, he discovered an economic method of separating silver from



lead ore. 'Pattinson's Process,' as it is now known, was a valuable discovery permitting the working of previously neglected lead mines. Also discovered a simple method of obtaining white lead which led to the discovery of oxy-chloride of lead; and a new process for manufacturing 'magnesia alba.' Vice-President of Section B (Chemistry) in 1838. F.R.S., 1852. Died near Gateshead.

PEARSON, Dr. WM., F.R.S. (1767-1847), *b.* Whitbeck. Educated at Hawkhead Grammar School, took orders, and went to live in Lincoln, where he constructed an astronomical clock and an orrery. In 1820, having moved to East Sheen and established an observatory there, he measured the diameters of the sun and the moon during a partial solar eclipse. It was mainly due to his influence that the Astronomical Society was founded (1820). F.R.S., 1829. In 1824 and 1829 published two quarto volumes of *Introduction to Practical Astronomy*, said, by Sir John Herschel, to be 'one of the most important and extensive works on the subject that has ever issued from the press.'

PERRY, Father STEPHEN JOSEPH, S.J., F.R.S. (1833-1889), *b.* London. The son of a manufacturer. Educated in London, Rome and Paris. Seven years after entering the Society of Jesus became Professor of Mathematics and Director of the Observatory at Stonyhurst (1860). His public scientific career began with magnetic surveys of France and Belgium, which brought him Fellowship of the Royal Society (1874). His services on astronomical expeditions to various parts of the world became indispensable and he undertook several of these on behalf of the Royal Society and the Royal Astronomical Society. He died on an expedition to photograph an eclipse of the sun, and was buried at Demerara.

RAWLINSON, CHRISTOPHER (1677-1733), *b.* Springfield, Essex. Second son of C. Rawlinson, of Carke Hall, Lancs. He devoted most of his time to Anglo-Saxon studies, but made valuable collections for a history of Lancashire, Cumberland and Westmorland. When he died (in London) his MSS. were sold for a few pence, with some furniture, and disappeared, but copies had been made of those relating to Westmorland and were used by Nicolson and Burn in their *Westmorland and Cumberland*.

SHAW, Rev. THOS., F.R.S. (1694-1751), *b.* Kendal. Son of a shearman dyer. Educated Kendal Grammar School and Queen's College, Oxford. While Chaplain to an English factory in Algiers he made a series of expeditions to Egypt, Cyprus, Asia Minor and 'the interior of Barbary.' Vicar of Godshell, Isle of Wight, 1734. Elected F.R.S., 1734, for *A Geographical description of the kingdom of Tunis*. He also wrote *Travels and observations relating to several parts of Barbary and the Levant*, which was valued for its descriptions of natural history, botany and geology. Died Bromley, where he was Vicar, after a period as Professor of Greek at Edmund Hall.

SIBSON, Dr. FRANCIS, F.R.S. (1814-1876), *b.* Cross Canonby, Cumberland. Studied medicine at Edinburgh and, after a short practice in Cockermouth, at Guy's Hospital. Surgeon to Nottingham General Hospital, 1835-48. F.R.S., 1849, after which he remained in London. Physician to St. Mary's Hospital. As member of Senate of London University, opposed admission of women to its degrees. Published important papers on changes of internal organs,



which were elaborated in 'Medical Anatomy' (1855-59). Died Geneva, buried Acton.

SIDGREAVES, Father WALTER, S.J. (1837-1919), *b.* at Grimsargh, near Preston, Lancs. Educated at Stonyhurst College. Entered the Society of Jesus in 1855. Twice Director of the Stonyhurst Observatory, viz., from 1863 to 1868, and again after the death of Father Perry, from 1889 till his own death in 1919. Accompanied Father Perry on expeditions to France for magnetic surveys in 1868-69, and to observe the transit of Venus in Kerguelen Island and Madagascar, in 1874 and 1882. Installed the photographically-recording magnetic instruments in 1866, which have continued in service ever since. Chief work was stellar spectroscopy, his photographs being awarded medals at the St. Louis Exposition of 1904 and at the Franco-British Exhibition in Paris in 1908. During his first directorship a new astronomical building was erected and equipped with an equatorial refractor of 8 inch aperture in 1867, and during his second tenure of office, this instrument was fitted with a larger objective of 15 inch aperture, as a memorial to Father Perry, in 1893. Died at Stonyhurst.

STURGEON, WM. (1783-1850), *b.* Whittington. Son of a cobbler, he was apprenticed to his father's trade, which he gave up for the Army, where he taught himself science. On leaving the Army he took up cobbling at Woolwich, and in his spare time was attracted to invention of scientific apparatus. Some of his inventions were :—(1) soft-iron electro-magnet, parent of the dynamo, of which he was the original discoverer (1823); (2) magneto-electrical machine; (3) electro-magnetic rotatory engine (1832). His practical inventions covered the whole field of electrical science. Established the *Annals of Electricity*, the first electrical journal in England (1836). In 1840 became superintendent of the Victoria Gallery of Practical Science at Manchester, and subsequently lectured and wrote widely. Collected his writings under the title *Scientific Researches*.

THRELKELD, Dr. CALEB (1676-1728), *b.* Keibergh, in the parish of Kirk Oswald, Cumberland. Educated at the Universities of Glasgow (M.A.) and Edinburgh (M.D.). Settled in Dublin where he divided his time between medical practice and Nonconformist preaching. Later gave up preaching and made extensive botanical expeditions all over Ireland. In 1727 published a *Synopsis Stipium Hibernicarum*, in which he described 535 species.

TROUGHTON, EDWARD, F.R.S. (1753-1835), *b.* Corney, Cumberland. At 17 went to London and became a scientific instrument-maker in company with his brother. His inventions included a new mode of graduating circles, the mural circle, by which polar distances were measured directly from the pole, the beam compass, and the hydrostatic balance. He was also famous for his telescopes, theodolites, and sextants, which were used on many important geodetical expeditions. Contributed to Brewster's *Edinburgh Cyclopaedia*. F.R.S., 1810. Died Kensal Green.

TURNER, Sir WM., K.C.B., F.R.S. (1832-1916), *b.* Lancaster. Apprenticed to a surgeon at Lancaster. Studied medicine at St. Bartholomew's Hospital and London University. Assistant Professor of Anatomy, Edinburgh, 1854. Professor, 1867-1903. F.R.S., 1877. President of the British Association,

1900. Principal and Vice-Chancellor, Edinburgh University, 1903. He was an admirable teacher and wrote many papers on anatomical subjects.

WALKER, A. (1731-1821), *b. Patterdale*. The son of a woollen manufacturer, he was self-taught, and eventually became a teacher of mathematics in Manchester. Later travelled in the north, giving lectures in physics, and finally settled down to lecture in London. Services engaged by Eton, Westminster and other public schools. Had an aptitude for mechanical invention, his inventions including a machine for raising water, a machine for watering land, rotatory lights for lighthouses, and methods of thermo-ventilation.

WARD, Rev. J. C. (1843-1880), *b. Clapham*. Educated at the Royal School of Mines, was appointed to the Geological Survey, and from 1869-77 was engaged in a survey of the Lake District. In 1878 was licensed to the Curacy of St. John's, Keswick. Pioneer in the use of the microscope for studying the composition of rocks. Published a short manual on Geology and wrote many papers for the Royal Society and the Geological Society. During residence at Keswick lectured on Geology and took a leading part in the foundation of the Cumberland Association for the Advancement of Literature and Science.

WATSON, RICHARD, F.R.S., Bishop of Llandaff (1737-1816), *b. Heversham, Westmorland*. Son of a clergyman. A Fellow of Trinity College, Cambridge (1760), he was elected to the Chair of Chemistry (1764), having 'never read a syllable on the subject nor seen a single experiment.' After 14 months' study started lecturing, his lectures being well attended, and nine years after the appointment (1769) he was elected F.R.S. for his publications on salt solutions. In 1771 became Regius Professor of Divinity, but continued to study and write on chemistry. In 1774 made a discovery which led to the black-bulb thermometer. Bishop of Llandaff in 1782. Buried in Windermere Church where there is a tablet to his memory.

WELD, Father ALFRED, S.J., F.R.A.S. (1823-1890), *b. Leagram Hall, near Preston, Lancs*. Educated at Stonyhurst College. B.A. (Lond.), 1844. Entered the Society of Jesus, 1842. Director of the Stonyhurst Observatory from 1845 to 1851, and again from 1856 to 1860. As Director he gave a strong impulse to development, initiating more systematic meteorological observations in 1845, and, under the advice and with the assistance of General Sir Edward Sabine, F.R.S., commencing the regular determination of the earth's magnetic elements, both of which series of observations have been continued uninterruptedly to the present time. It was owing to Father Weld's successful work that Stonyhurst was recognised as a meteorological station in connection with the Kew Committee. His scientific work at Stonyhurst came to an end upon his being called to high office in his Order. Died at St. Aidan's College, Grahamstown, Cape Province.

WHEWELL, WM., F.R.S. (1794-1866), *b. Lancaster*. The son of a master carpenter. Educated Lancaster Grammar School and Trinity College, Cambridge. He helped to introduce analytical methods of continental mathematicians. Elected F.R.S. in 1820, having previously published works on *Mechanics* and *Dynamics*. Occupied the Chairs of Mineralogy (1828-32) and Moral Philosophy (1838-55), during which time he wrote a history and a philosophy of the inductive sciences, and published in the Proceedings of the



Royal Society important memoirs on tides. As Vice-Chancellor of the University introduced the triposes of Moral Science and Natural Science (1840). President of the British Association in its tenth year (Plymouth, 1841). Said that there was 'scarcely any subordinate office of labour or dignity in the Association which he had not performed at one or other of its meetings.' Suggested the annual reports on the State of Science, and contributed to the reports of the first Research Committees. Died and was buried in Cambridge.

WILLAN, Dr. ROBT., F.R.S. (1757-1812), *b.* Sedbergh. Studied medicine at Edinburgh. Practised in Darlington and London. Physician to the Public Dispensary, London, 1783-1803. Received Fothergillian Medal from Medical Society of London for classification of skin diseases, 1790. He was the first in this country to arrange skin diseases in a clear and intelligible manner and fix their nomenclature. His classification is still used by the profession. Published, in parts, *Description and treatment of Cutaneous Diseases* (1798-1808). Elected F.R.S., 1809. Died Madeira.

WILLIAMSON, Sir JOSEPH, F.R.S. (1633-1701), *b.* Bridekirk, near Cocker-mouth. Son of a clergyman. Educated St. Bees, Westminster School, Queen's College, Oxford. During a hectic political life found time for interest in antiquities. Elected to the Royal Society by the original Council in 1663, he became its second President (1677-1680), and was succeeded by Sir Christopher Wren. Collected many valuable manuscripts relating to heraldry and history. Died Cobham, Kent; buried Westminster Abbey.

WOOD, WM., F.R.S. (1774-1857), *b.* Kendal. Educated for the medical profession at St. Bartholomew's Hospital, he practised first near Canterbury, and then in London till 1815, when he became a bookseller in the Strand. Took a keen interest in natural history. Elected F.R.S. in 1812. Wrote books on zoography, conchology, insects, and British freshwater fishes; edited several others, and, besides illustrating his own works, drew pictures for other authors.

WOODVILLE, WM., M.D. (1752-1805), *b.* Cocker-mouth. Studied medicine at Edinburgh and on the continent. Practised in Cumberland, Denbigh and London. In 1790 published the first volume of his great work on *Medical Botany*, in which he gave a description of all the plants mentioned in the catalogues of the *Materia Medica* published by the Royal Colleges of Physicians of London and Edinburgh. The third edition of this work extended to five volumes.



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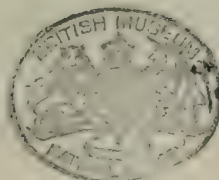
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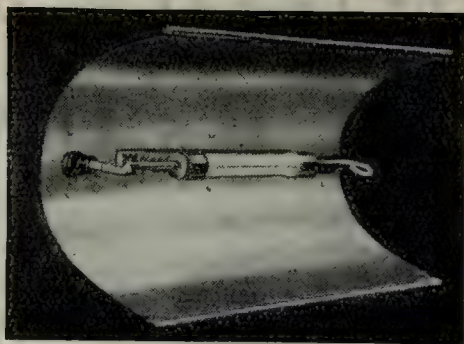
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